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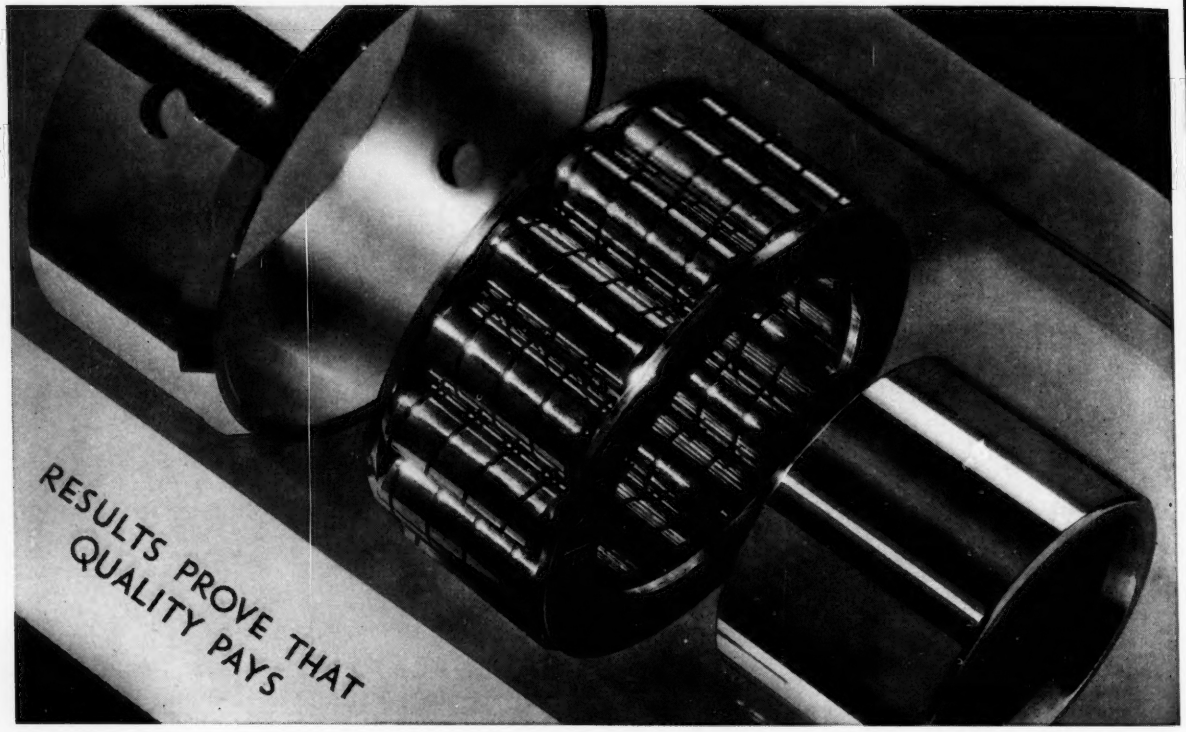

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AGRICULTURAL ENGINEERING

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A Grain Combine for the Corn Belt[1]

By I. D. Mayer[2]

COMBINED harvester-threshers which are to be satisfactory in the corn belt must be capable of harvesting a variety of crops under widely different conditions of soil and plant growth. Combines now in use in this territory are, for the most part, just smaller models of the machines designed for the wheat-growing regions of the Great Plains, but they have demonstrated their ability to harvest the small grains and soybeans of the corn belt with approximately one-fourth the man labor and at two-thirds the total cost of harvesting by the binder-thresher method. This convenience and economy of operation has definitely established the combine as one of the corn belt farm implements.

While the many advantages of the combine method of harvesting are clearly evident, it must be recognized that farmers operating combines in the corn belt have encountered many difficulties, at least some of which could be overcome by machines designed essentially for this region.

It is, therefore, the purpose of this paper to direct attention to some of the difficulties which have been experienced with the combines now in use in this region and to set out some of the requirements which a combine should fulfill in order to be a satisfactory machine for corn belt conditions.

While the relatively small farms and small fields of the corn belt might tend to limit combines to the smaller sizes, these should not be wheat belt machines scaled down throughout in proportion to the reduction in the length of the cutter bar. To be successful the corn belt combine must be able to handle long and heavy-strawed grains, even when they are cut low to save all of the straw. It should be able to cut close to the ground so as to harvest such crops as soybeans and clovers without serious losses. It should be able to cut high enough to harvest sweet clover, Japanese millet, and grain sorghums. The machine must be constructed strongly enough to withstand the strains of these heavy, coarse-stemmed crops and rank-growing weeds, but it must also be light enough in weight so that it can be used on loose or soft soil.

The weight of the combine may be the factor which will determine the size of the machine used. This would be especially true in harvesting soybeans, the crop on which the combine excells all other harvesting implements, for soils in soybean fields are usually quite loose and are frequently wet and soft during the combining season. The machine must, however, be large enough to harvest a sufficient acreage of all crops during the average season so as to be a profitable investment. It should, however, be of such size that its power requirements can be amply satisfied by the tractors most generally available in the corn belt.

Tractors Available. A large majority of the tractors of this region are of the two and three-plow sizes, and a rapidly increasing portion of these tractors are of the general-purpose type. Combines for the corn belt should be designed to operate conveniently and efficiently with these general-purpose tractors.

The question of the source of power for the operation of the combine is a debatable one. Both the power take-off and the auxiliary engine type of drive have enthusiastic supporters. Efficient operation of the machine requires a uniform speed of the threshing and cleaning mechanisms. This necessitates a reserve of power to overcome the irregularities of feeding and the variations in the crop harvested. Experience in the field has demonstrated that, if the tractor used had sufficient reserve power, even under somewhat adverse ground conditions, to maintain a uniform cylinder speed when green weeds or bunches of grain entered the cylinder, power-take-off operation was satisfactory. If, however, as was frequently the case, the tractor had sufficient power to maintain uniform operation under good conditions only, inefficient harvesting usually resulted where the going was not the best. For efficient power-take-off operation the power requirements of the combine

[1]A contribution of the Committee on Combine Development presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers held at The Stevens, Chicago, November 1932.

[2]Station experimentalist, department of agricultural engineering, Purdue University, Lafayette, Ind. Assoc. Mem. A.S.A.E.

must be very closely correlated with the power available at the tractor. This relationship of the tractor and combine should be considered for conditions as usually found in the harvest field of the particular region in question rather than for optimum conditions. For much of the combining in the corn belt, particularly in the harvesting of soybeans, conditions are quite severe and reserve power is necessary for satisfactory operation.

The lower first cost and the reduced weight of the power-take-off machine have frequently appealed to the prospective combine owner, but after he has had experience with the less favorable field conditions often encountered, he has frequently expressed a preference for the motor-driven machine. In a recent survey of combine owners ten out of twenty-four who had power-take-off machines now expressed a preference for the auxiliary engine type of drive. Sixty-five of the farmers interviewed had auxiliary engine driven combines and all expressed a continued preference for this type of drive.

The power available will be a vital factor in determining the type of drive and the sizes of combines which will be most popular. The size of other implements which the farmers are, or have been using, will also affect the size of machine they will buy. A survey of present owners of combines in the corn belt indicated a preference for machines with 8 to 10-ft cut. Most of these men indicated 8-ft cut as the minimum desirable, and 12 or 14 ft as the maximum length of cutter bar practical under their conditions. Since these farmers had been using 8 and 10-ft binders for a number of years they could hardly be expected to purchase combines with shorter cutter bars than the binders, unless the smaller combines were decidedly more efficient or noticeably more economical than the larger sizes.

Ownership. While there will probably always be some fairly large combines used for custom work in the corn belt, the apparent risks involved in allowing grain to stand until ripe, and the urgent desire on the part of the farmer to have his grain cut, will greatly handicap custom combining. Experiences of the past six years indicate that cooperative ownership of combines, except in the cases of relatives, had usually not proved satisfactory. After two or three years of cooperative ownership the combine had usually passed into the possession of one of the partners and he harvested the grain of the others as custom threshing. It appears as if the future combines in the corn belt will probably be owned and operated by farmers who have more than the average acreage of crops, or by men who like to operate machinery. These men will probably do a small amount of custom threshing for their neighbors in addition to their own harvesting.

THE TRANSPORTATION OF COMBINES AN IMPORTANT PROBLEM

Transportation. In order to harvest a sufficient acreage annually to make the combine profitable, most of the machines must be transported to several fields each season. Time spent in transportation is usually valuable harvesting time lost. For the combines studied, an average of 20 min for two men was required to prepare them for transport and a similar amount of time was needed to place them back in readiness for harvesting after moving. Some machines required much longer than this. Combines should be so constructed that two efficient men can prepare the machine for transport in ten minutes, and set it up again for harvesting in a similar time.

Some machines, however, when prepared for transport were still too wide to pass through the average farm gate readily. Combines with grain tanks or other parts supported above and outside the wheels have been difficult to get through gates with high posts or gates adjacent to buildings or through bridges or culverts with high sides. If the weight of the machine was not fairly uniformly distributed on the wheels, the machines have been difficult to handle on the road, particularly on pavements.

Satisfactory transportation of a combine in this region demands that, when prepared for transport the overall width be less than 11 ft 6 in, that the height be less than 12 ft, that the weight of the machine be so balanced that the combine will trail well on a paved road, and that the wheels have smooth rims, that is, no protuberant spokes, bolts, or rings. It seems advisable that the combine be so designed that it could be transported without damage at a speed of about 10 to 15 miles an hour on paved highways.

Much of the wear and tear on combines has been caused by the vibration of the machine while moving in the field or over the road. The use of springs, shock absorbers, or even rubber tires would add very materially to the life of the combine. Many of the breaks which occurred in the field were traced to a nut or bolt loosened by the vibration of the machine during transportation.

Crops Harvested. A combine for the corn belt must be capable of harvesting a great variety of crops. Last year's report of the A.S.A.E. Committee on Combine Development indicated that twenty-nine different crops had been harvested by the combine in the United States. Seventeen of these crops are known to have been combined in the corn belt, and it is possible that still others were combined.

In order to cut and thoroughly thresh and clean such a variety of crops without damage to the seeds, many adjustments and special attachments were of course necessary. It should be possible, however, to make these necessary changes without any extensive alterations of the machines. The farmer should be able to reduce the cylinder speed for threshing beans without requiring the services of a machine shop or a skilled mechanic. It should be possible to change or adjust concaves easily and quickly. Screens should be adjustable, or at least easily interchangeable.

CUTTING AND GETTING GRAIN INTO CYLINDER PRESENTS DIFFICULTIES

Platform Problems. A survey of combine harvester problems indicated that more difficulties were encountered in the cutting of the grain and getting it into the cylinder than in all other parts of the combine. A machine which will cut cleanly and handle crops 6 in or 6 ft high, standing grain or lodged grain, green or ripe material, cut 3 in from the surface of the ground or 3 ft from the ground, must indeed be a versatile implement. Yet these are the requirements asked of the combine in the corn belt.

Since the combine was originally designed to handle headed small grains, little difficulty has been experienced in these grains, except in cases where the cut straw was too long for the width of the platform. In such cases the heads of the grain hit the rear platform shield and bounded back sufficiently to hang on the sickle bar until the straw could be turned sufficiently to be put entirely on the draper. This usually caused dragging of the grain and clogging of the sickle.

Soybeans and clovers must be cut within 3 in of the ground if severe losses are to be avoided. Yet, in these crops the combine must also cut weeds, often still green and more than 4 ft tall. These weeds must be laid back upon the draper so that they can be carried into the cylinder. Considerable difficulty has been experienced, particularly on the narrow drapers, in conveying this tall-growing material into the cylinder. Frequently it was necessary to employ a man on the rear of the combine platform to assist the coarse material into the feeder house. If these coarse weeds collected into bunches before reaching the cylinder a slugged cylinder was usually the result. A clutch or draper stop controlled by the operator could under such conditions have made possible the gradual feeding in of this material, thereby reducing the sudden strain upon the combine and also save time and arduous labor for the operator. Occasionally when cutting low, small stones are picked up by the platform. If the draper could not be stopped quickly these usually got into the cylinder and broke either the concave or the cylinder or both, resulting in costly delay while repairs were made.

While the average soybean field would have the rank

(Continued on page 96)

Combining Soybeans in the South[1]

By R. B. Gray[2]

AT THE request of farmers in the Mississippi Delta and the Delta Branch Experiment Station, observations were made the past two seasons by the U.S.D.A. Bureau of Agricultural Engineering on the operation of typical 10-ft grain combines, complaints having been made that these machines could not be used to harvest beans in that section.

Previous studies have shown that the combine has proven quite successful for harvesting soybeans in the corn belt states. Here the fields are fairly free of weeds and the bean plants are dead at harvest time. While the acreage of soybeans on the average farm may not justify the purchase of a combine, on many of these farms the total acreage of all crops on which this machine can be used is frequently sufficient to warrant its purchase.

In the eastern and southeastern states, the combine can be used for harvesting operations, but in most cases the total acreage of crops which it could harvest is not sufficient to justify the purchase of so large and expensive a machine.

In the lower Mississippi Valley, especially in what is generally known as the Delta region of Mississippi, and certain parts of Arkansas and Louisiana, the soybean plants are seldom dead at harvest time and the fields are very often badly infested with weeds which often grow to a height of five or more feet. Due also to the rank growth of the bean plants, lodging seems to be more serious in that region. From the foregoing, therefore, it can be seen that in the Delta region there are two conditions that make the use of the combine difficult, namely, (1) the bulky nature of the green plants, coupled with the frequent heavy growth of weeds hinders the operation of the machine, and (2) the combine being too large and expensive for use on the average farm.

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[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers held at The Stevens, Chicago, November 1932.

[2]Chief, Division of Mechanical Equipment, Bureau of Agricultural Engineering, U. S. Department of Agriculture, Washington, D. C. Mem. A.S.A.E.

The following observations made near Greenville, Mississippi, during the past two seasons by the Bureau of Agricultural Engineering indicate why the farmer has registered his complaints:

In Field No. 1 the soybeans were badly lodged and the farmer had tried direct combining with little success. He had removed the sickle from the combine, raised the platform to its maximum height, removed the reel, constructed a wall over the front edge of the canvas to about the height of the back stop, and had attached a hay loader behind the platform. A tractor mower was used to cut the soybeans, two rows at a time. The mower was followed by the combine, the hay loader acting as a pick-up. Two extra men were employed, one to prevent the soybeans from falling upon the canvas in bunches and the other to force the soybeans into the cylinder when they would accumulate in the feeder housing. The regular pick-up had been tried, but the soybean vines would hang to the pick-up teeth and be pulled back under the pick-up.

In Field No. 2 the soybeans stood 3 to 4 ft high, were erect, and the plants were well matured. The combine worked fairly well in this field, cutting two rows at a time. Even under these favorable conditions, some parts of the combine were subjected to excessive strain. The farmer reported that seldom was he able to run a full day without breakage. During observation of the machine several teeth were stripped from a gear which drove the reel and sickle.

In Field No. 3 the soybeans were badly lodged and an attempt was made to harvest direct. In order to get the cutter bar under the vines it was necessary to set it to operate as near the ground as possible. With the cutter bar in this position the platform and platform canvas were tilted forward and vines would accumulate over the sickle. The vines would also ball up at the outer end of the cutter bar. With wheat and other small grain the reel can usually be set in such a position as to push the grain back on the canvas. With the mass of vines encountered in soybean harvesting, the reel is not adequate. If set low enough to push the vines back on the canvas, it is likely to be broken. The regular guards on the cutter bar are also too close together for soybeans in the South. On two of the machines every other guard had been cut off, and better results were obtained.

Field No. 4 had been mowed by a horse mower in the early morning and toward noon harvesting from the swath with a combine with pick-up attachment was started. An extra man with a pitchfork was required to help the mat of beans turn the first corner so the platform canvas could properly function. This man also pitched out the larger weeds as they were encountered. The outer sickle guards, not covered by the pick-up attachment, hooked the larger weeds and required frequent cleaning. The estimated loss of beans was 25 per cent.

Field No. 5 was mowed with a tractor mower, windrowed with a horse-drawn side rake—one swath of the rake per windrow—and then harvested by combine with pick-up attachment. Many beans were knocked out by action of the side rake in tearing away its swath from the other cut beans. The rope-like windrow had to be guided up the canvas and frequently choked the threshing unit even though the forward speed was only one mile per hour. The owner estimated the loss at one-third of the crop.

Field No. 6. The owner was starting a new combine. Thirty to forty days previously he had last viewed this field, which was then free of weeds. Now the field was infested with weeds, a large proportion of which was as high as the combine. Direct combining was attempted but clogging of the sickle guards and the outer divider by weeds made this impossible. To get started a few rounds were made

with a mower and negroes pitched the vines onto the platform canvas.

In the Mississippi Delta the operation of combining is referred to as saving, which appears to be literally true, for if a farmer can save 60 to 75 per cent of his beans he is lucky. If a machine could be devised that would enable him to save an additional 15 or 20 per cent, the soybean saver would soon pay for itself.

A number of changes have been made by the manufacturers, such as a vertical sickle at the outer divider for parting the tangled mass of vegetation, a hoop to replace the outer divider for the same purpose, adjustable reel, provision for changing the reel to four slat, and alternations of sickle guard.

These changes, no doubt, are of considerable help, but the general opinion in the South seems to be that the present combine is not suitable for harvesting soybeans in the Delta region. Apparently every conceivable way has been tried to make these machines work, as no other harvester is available for the crop. The statement made repeatedly in the South is that harvesting is the limiting factor in soybean production.

Farmers are enthusiastic about soybeans. Soybeans are soil builders and are valuable for both food and feed. At a soybean conference in Washington early in September, an exhibit of over two hundred products derived from soybeans was displayed. This included cooking and paint oils, stock feed, angel food cake, candy, soap, rubber, and even hot dogs. When properly prepared, soybeans are also a palatable food for human consumption. Recently, a demand from foreign countries was responsible for large shipments abroad.

In the Delta region of the three states, there are probably three million acres where soybeans could be grown. In rotation, probably one millions acres would be a potential yearly acreage. According to the 1932 U. S. Department of Agriculture Yearbook, only 141,000 acres were raised for seed in the states of Mississippi, Arkansas, and Louisiana last year. With such large possibilities limited by harvesting facilities it would seem that the agricultural engineer could well afford to use his ingenuity and add still further to his laurels by getting away from the conventional design and building a small combine, including some of the following features.

1. Cut a six-foot swath.
2. Pass the material straight through the machine in place of having so many corners for the mass of material to turn.
3. Arrange cutter bar so as to cut beans within two inches of ground; construct reel so as to gradually pull the bean vines in whatever condition onto the platform without shock.
4. Power take-off so constructed that its speed would be independent of the forward speed of the tractor.
5. Probably an overall width of 12 ft.
6. A weight of 3,000 to 4,000 lb.
7. A maximum cost to the farmer of $500.
8. Adaptable for small grain. This would make it adaptable to thousands of farms throughout the country which grow only a limited acreage of small grains.

The Barge Method of Combine Harvesting[1]

By J. K. MacKenzie[2]

THE combined harvester-thresher made a tentative appearance in southwestern Saskatchewan in 1922. In 1924, only five were in use, but in 1927 the introduction of the windrow harvester gave such an impetus to the combine that they were used in thousands. It was demonstrated that the machine could harvest grain crops at a much lower cost per acre or per bushel than could the binder and separator. This fact still stands notwithstanding a great reduction in labor costs, which is one of the major cost items in stationary threshing.

It is evident that farmers in general will not go back to the binder and separator. On the contrary, many of them have been seeking ways and means of making the combine adaptable to their own peculiar conditions. The most promising development in that regard is the device known as the "header barge," which in all essentials is merely a form of mechanized stacking. It avoids the expense of binder twine and eliminates a vast amount of the heavy labor connected with the ancient method of stacking, and, at the same time, promises to retain all of the undoubted advantage of stacking, namely, the practical elimination of the weather hazard with its consequent loss in grade and loss in net yields per acre.

The years between 1928 and the present saw a gradual spread of the stacking method of harvesting, particularly where this device was used as an aid or adjunct to the combine. E. A. Hardy, agricultural engineer at the University of Saskatchewan, in a letter, dated October 28, 1932, makes the following significant statement:

"It is quite outstanding, in our opinion, that we find the barge coming into use in a section of the country like Glidden and Kindersley, where the land is perfectly level, is of reasonably uniform soil and is practically ideal for harvesting grain with the combine. However, upon studying the past years, the farmers who are using the barge were the first farmers to use the combine and have had experience with the combine since 1924, and have definitely come to the conclusion that the risk of more than two or three hundred acres of harvest is greater than the average farmer can take, when planning to straight combine. They have consequently been barging anywhere from 300 to 500 acres in preference to using the windrower.

"The windrower has not protected the grain from sprouting during the wet periods, or from snow during the earlier snows in October. They find that the grain in the barged stacks dries, and also the weeds in the stacks cure, so that the grain may be threshed and separated from weeds much more safely and satisfactorily than when using the windrower, and that a part of the grain could be put in such a condition during the earlier part of the harvest that it is practically safe even though the winter sets in earlier. They are then able to delay straight combining until the crop is actually ready for it, without having the entire crop exposed to the weather which follows the middle of September.

"I have had a number of interviews with men who are in a position to know the financial position of the farmers in the combine areas, and they gravely fear the results of our farmers who continually plan on straight combining their entire area, where it is necessary to do more than 500 or 600 acres with one machine. It is obviously impossible for the average farmer to have more combines at the present price of wheat. The average farmer who is studying the harvesting situation is coming to the realization that, if it is possible to cut and stack a portion of the crop economically and then straight combine the remainder, after which the stacked grain is threshed with the combine, the enormous losses experienced during the falls of 1927, 1928, and 1929 may be avoided and the cost of harvesting will be much less than when using the binder and threshing machine, and yet the risk will be reduced much more than when attempting to straight combine. We feel that, where a farmer is in an area

[1]Abstract of paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers held at The Stevens, Chicago, November 1932.

[2]Agricultural engineer, Caterpillar Tractor oCmpany. Assoc. Mem. A.S.A.E.

Two views of a windrower and header barge in operation near Three Hill, Alberta, in September 1932

suited for the combine, undoubtedly all the grain which can be straight combined will be handled in the most economical way. We believe, however, that the header barge will probably replace the use of the windrower, and, in a considerable number of instances, the use of the binder and the stook."

Another important piece of evidence resulted from the harvesting investigations conducted by the Grain Research Committee of the National Research Council of Canada. A grade and moisture survey was conducted during the harvest season just past in an area which extended from the International Boundary to Red Deer, and from the foothills to the Saskatchewan border. In addition, certain specific experiments were carried out whereby a direct comparison was made, under similar conditions, of different methods of harvesting, with particular reference to the combine and the barge.

Professor Donald Cameron of the University of Alberta, who was in charge of this investigation, states:

"Sampling was started at Warner on August 19, and at this time combining was in full swing from Lethbridge south of the Montana border, but very little stook threshing was being done. At the time sampling was started the weather was extremely hot and dry . . . . The majority of the grain sampled at this time had been exposed to very little if any rain, and the period of hot weather had ripened it very rapidly. Consequently, practically all of the grain coming into the elevators was dry . . . . the majority of it to be under 14 per cent moisture. In spite of this, many of the elevator operators were spending a good deal of their spare time in turning combined grain.

"After being in the elevator 24 and 48 hr, certain bins of combined grain would show considerable heat, and the grain would be clammy to the touch. Wheat in one bin at Stirling in which thermometers were placed registered 87 deg F after four days storage, yet this sample had been taken in as dry. The elevator operator was turning this bin of grain once a day and sometimes twice.

"The same experience was common to 50 per cent of the elevator operators in the Lethbridge, Coutts, and Macleod areas. Combined grain was coming in dry, yet elevator operators felt it necessary to keep turning the grain in certain bins, and in most cases after this treatment the grain would cool down and come out all right. It is common knowledge in the grain trade that no amount of turning such as elevator operators are able to give the grain, will reduce its moisture content. This fairly well proves that it is not moisture alone that is causing the trouble.

"Green kernels and immature grain are apparently very important factors in determining whether combined grain will keep in storage or not. In some cases where the bulk of the grain in the bin was dry and mature, trouble could be traced to the first couple of loads that came from the field, or to the loads that came from a field which contained small hollows or depressions in which the grain was greener than that in the rest of the field."

To the foregoing may be added as a postscript the following statements:

"Combined grain which was fully mature would keep without difficulty, even with a high moisture content, but many bins of dry combined grain which contained small quantities of green kernels and green weeds would start heating and the elevator operator would have to turn it to keep it from spoiling . . . .

"Swathed grain does not give the same trouble as straight combined grain in storage, the chief criticism of this method being the heavy losses caused by bad weather conditions through shrinkage, bleaching and sprouting, and consequent loss of grade. . . . ."

In regard to the barge, Professor Cameron states "The grain from the barge stacks was in all cases of a superior quality to that harvested under comparable conditions by other methods. This was true in an experiment carried out in the Edmonton district where the grain from four methods of harvesting was compared in the one field, and it was also true in the general survey."

It would appear from all the evidence available that straight combining is the most economical method of harvesting, but it is subjected in many areas to the disadvantage of having the grain heat in the bin, and its use is confined to a comparatively small acreage per season unless the operator is willing to gamble on the weather. The windrow harvester successfully overcomes the problem of heated grain, but leaves the operator open to serious losses in grade and yield. Grade and yield losses are usually not so high when the binder and separator are used, although in seasons of heavy rainfall, shocked grain suffers heavy losses from bleaching and sprouting, but this method of harvesting is undeniably higher in cost than any system in which the combine is used. The use of the barge with the combine enables the operator to retain all of the economy of the combine and at the same time secure a grade of grain which, according to Professor Cameron, "was in all cases of a superior quality to that harvested under comparable conditions by other methods."

The following are comments made specifically on the barge by Professor Cameron:

"Barges were operated this year practically all over the province of Alberta, but by far the greatest number were used in the southeastern portion of the province in the area adjacent to the Acadian Valley where the idea originated in Alberta in 1924. Along the Goose Lake Line of the C. N. R., from Cereal east to the Saskatchewan border, I would say that between 35 and 40 per cent of the wheat crop was harvested by this method with very satisfactory results. . . . .

"One farmer in the Hanna district used the cutting table of a 20-ft combine attached to a barge 8 by 16 by 8 ft, the whole outfit pulled as a unit with a 30-hp tractor, at 4 mph. With this outfit he averaged 80 acres per day with the aid of two men building the stack in the barge, one man operating the header, and himself on the tractor. His actual cash outlay for putting the grain in the stack was 25 cents per acre. This included wages for three men at $2.00 per day, wages for himself at $4.00 per day, and fuel and oil for the tractor. It should be pointed out that although this farmer was using a 30-hp tractor, a 15-30-hp machine was capable of moving the outfit at a slightly lower speed.

"During the course of the survey hundreds of barge stacks were examined, practically all of which in southeastern Alberta had been exposed to between 2 and 5 in of rain. In only two cases was any spoilage noticed . . . . In both cases the owners attributed the damage to the

fact that on the afternoon the stacks were put up they were exposed to over one inch of rain in four hours. The stacks were not big and were pretty thoroughly soaked. A period of misty weather followed and the owners became alarmed at the wet condition of their stacks and proceeded to tear them open. Stacks that were left unopened came through without any spoilage other than some discoloration on the north side. . . .

"Many farmers who have been combining have taken their swathers and cutting platforms and used them as headers attached to the barge, and later used the combines to thresh the barge stacks. This, by the way, makes an ideal arrangement and is much more satisfactory than using a binder as the heading device."

All indications point toward the conclusion that the barge system of harvesting is going to come into much wider use than it has up to now. The economy of operation and the improvement in the quality of the grain harvested by this method makes it worthy of the most serious consideration.

A Grain Combine for the Corn Belt

(Continued from page 92)

weed growth in the lower portions, the higher and less fertile soil would usually have few weeds and very short soybeans, probably less than 12 in tall. If the reel were set so as to lay these short beans back upon the draper, it would receive terrific strains and frequently had one or more slats broken when in the rank weeds, because the cutter bar had to be kept low to get the beans. If the reel were set to handle the weeds, many of the high quality but short stemmed beans were dropped to the ground in front of the platform and were lost. It would have been impractical to stop to adjust the present type of reel each time the conditions changed. For example, in a 20-acre field 40 rods wide with one low weedy strip across it, the reel of an 8-ft combine should have been changed 160 times. Assuming a minimum of three minutes for each change, eight hours would have been consumed in changing the reel. A reel adjustable from the operator's platform, similar to that on a binder would make these adjustments possible without stopping the combine.

Over 90 per cent of the combine owners asked, in a survey, stated that a reel adjustable from the operator's platform was needed. Some had already constructed mechanisms for their own combines for adjusting the reel up and down. Some farmers stated that they would be willing to pay as much as $50.00 extra to have the adjustable reel. More of them set a lower value on this convenience, while, as would be expected, most of them felt that this should be provided at no extra cost to them.

In tall grain or heavy weeds relatively large reels, five feet in diameter or larger, have been found more effective than the smaller reels. Reducing the number of slats on the reel provided more space for the tall weeds and caused less strain upon the reel, without materially reducing the efficiency of the reel in rank growth.

Threshing. Because of the wide differences in the quantity of material to be handled for each foot of cutter bar for the various crops, in the corn belt, there did not seem to be the same correlation between length of cutter bar and size of feeder house, length of cylinder and separation capacity, as existed under wheat belt conditions. Even with a very short cutter bar rather large bunches of long, stiff straw and weeds entered the machine. It seems that it would be logical to set up certain minimum requirements which will permit these coarser materials to pass through the machine smoothly and then increase the volume of material entering the machine in lighter grain by increasing the width of cut or the rate of travel of the machine.

As the number of combines in the corn belt increases more of the straw from combines will be reclaimed for feed and bedding. When straw was to be reclaimed the stubble was usually cut lower and a greater volume of straw passed through the machine. The combine for the corn belt should have sufficient straw capacity to handle the crop efficiently when only 8 to 12 in of stubble is left in the field.

Straw Equipment. Straw spreaders for the corn belt must spread the straw uniformly and thinly. Large bunches of straw will smother the clover and grass crops which usually follow the small grains.

Equipment for reclaiming the straw from combines will become of increasing importance as the number of combines increases and the old straw stacks become scarce. Because of the relatively high cost of reclaiming straw with the equipment now available and the low price of straw in the stack or bale, little effort has been made by farmers to reclaim the straw from the combines. Indications are that the straw problem will be of increasing importance in the future and the solution of this problem will have a marked influence upon the future use of the combine in the corn belt.

Stationary Thresher. The combine has not been used very much as a stationary thresher. Nevertheless, by making a few changes in the feeding mechanisms and by providing a straw carrier, it can be satisfactorily used for stationary threshing. This use appears to have possibilities for regions in which the straw is needed for bedding purposes.

Windrow and Pick-Up Attachments. A combine for the corn belt cannot be fully utilized without the windrow and pick-up attachments. These accessories to the combine are particularly useful in sections which grow oats and barley or other weak-strawed grains which strawbreak or shatter badly, and also in regions which harvest clover seed.

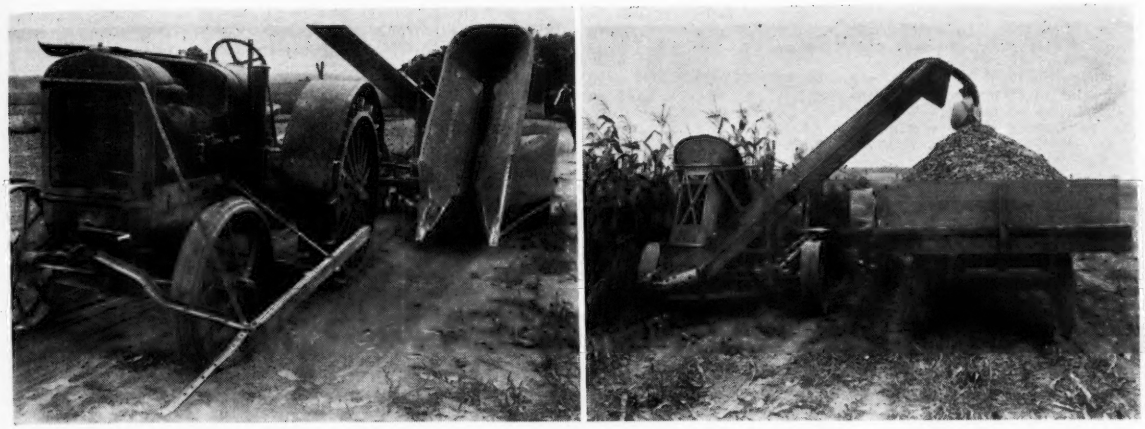
For its most effective use in this region the windrower should be an independent machine. It has frequently happened that the combine was cutting wheat direct at the same time that oats should have been windrowed. In such cases if an independent windrower and two tractors were available both operations were carried on at the same time. If only one tractor were available, oats were windrowed early in the morning before the combine could start to thresh wheat and after the combine stopped in the evening.

Pick-up attachments should be quickly and easily applied, for frequent changes are necessary in the small fields of the corn belt. It would be desirable to have the pick-up so designed that it need not be removed from the combine platform for transportation.

Hillside Type of Combine. Most of the combines now in the corn belt have been used on fairly level fields only, and very little loss of grain has resulted from crossgrades. However, as the use of the combine spreads, these machines will be used on the more rolling land. Undoubtedly successful operation on the rolling land will require the hillside type of combine. They will probably have to be of a fairly small size, if they are to be drawn by the tractors now most used in those regions.

SUMMARY

The combine desired by the farmers of the corn belt is one with great flexibility. It should be capable of harvesting a great variety of crops; it should have a wide cutting range; it must have sufficient capacity to handle long and coarse-strawed grain; it must be strong and durable, yet relatively light in weight so that it can be pulled over soft fields by the medium size of tractor; it should be capable of quick, easy transportation from field to field; it should be a simple machine which can be kept in adjustment and repair by the farmer.



Two views of the field ensilage harvester. The guard shown on the tractor (at the left) was improvised to prevent the wheels of the tractor from running over stalks badly blown down

A Cost Study of Filling Silos with the Field Ensilage Harvester[1]

By P. I. Wrigley[2] and A. W. Clyde[3]

DURING THE PAST three seasons a 1928 model field ensilage harvester was used for filling silos at The Pennsylvania State College. Previous to this time the silos were filled with a stationary outfit.

Starting with the 1931 season, complete records were kept of the machine and the labor used in connection with its operation in an attempt to determine under what conditions the purchase of such a machine could be economically justified.

The corn was blown down so badly in 1931 that about 13 per cent of the ears were touching the ground. In the first field the harvester worked fairly satisfactorily after a guard, to push the fallen corn away from the tractor wheels, had been attached. In the second field, the corn was down lengthwise of the rows, so that it came into the machine in bunches. Scarcely a load was cut without several stops due to clogging. Another factor contributing to this was the rather fast ground speed of the tractor and consequent lack of cutting capacity for the heaviest corn. About 10 per cent of the corn was missed so that it had to be gathered by hand or wasted. Breakdowns were numerous and considerable time was lost because the whole crew was idle if the harvester was not cutting corn continuously.

The harvester was an obsolete 1928 model with many weak parts which have been eliminated in later designs. It had given satisfactory service during the previous season, when the corn crop was very light, but, with the adverse conditions existing in 1931, the loss of time due to breakage was extremely great.

For the 1932 season the machine was rebuilt, the main changes being a stronger sickle, a more direct drive for the sickle, and an improved assembly for driving the gatherers. The speed of the tractor was also slowed down by changing its gear ratio so that it pulled the harvester 2⅓ mph in first gear and 3 mph in second gear. (First gear was used mostly in 1932). These changes practically eliminated mechanical trouble in 1932.

A stationary cutter was used to ensile the corn cut in opening up the fields in which the harvester was used. The harvester was pulled by a three-plow tractor. The blower at the silo was driven either by a two-plow tractor or by an electric motor. Since there was no meter to show the amount of electricity used, the expense was figured as though the tractor had been used all the time. One man was in the silo, one ran the small tractor and helped unload wagons, another ran the large tractor, and four or five teamsters, depending on the distance, hauled the corn to the silo.

The average distance traveled by the teams in going to and coming from the corn fields was about 1.8 miles, which, with the approximately 0.4 mile while loading, made an average distance of 2.2 miles traveled by the teams for each load hauled. When working in the nearest fields four teams were sufficient, but for the more distant fields five teams were necessary. With a total distance of not more than one mile for the round trip and not taking time to weigh the loads, three teams would have been enough if the yield was approximately ten tons per acre. If the strength of the teams or the conditions were such that an average load of 3600 to 3800 lb could not be hauled, the number of teams would have to be increased accordingly. The average yield of corn cut by the harvester in 1932 was 10.1 tons per acre.

Accompanying this article is a summary of the results of the use of the ensilage harvester in 1931 and 1932. Depreciation on the harvester was figured at 12½ per cent of the cost, and on the blower at 6¼ per cent of the cost. Repairs were included at actual cost, including the cost of getting and putting them on the harvester. The costs for 1931 are given as indicative of what a farmer may expect under the most unfavorable conditions, such as with a machine nearly worn out. The costs for 1932 are indicative of what may be expected under the most favorable conditions as with a new machine and corn standing well. Accordingly interest was charged on only one-eighth of the cost of a new harvester for 1931, but was charged on the full new cost for 1932. The average charge for the

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Costs of Harvesting Corn with Ensilage Harvester on the Pennsylvania State College Farms

	1931	1932
Depreciation of harvester, 12½ per cent	$ 65.00	$ 65.00
Depreciation of blower, 6¼ per cent	14.38	14.38
Depreciation of wagon equipment, 6¼ per cent	3.44	3.44
Interest on harvester, 6 per cent	3.90	31.20
Interest on blower, 6 per cent	7.33	7.33
Repairs on blower, 2 per cent	4.60	4.60
Interest on wagon equipment	1.76	1.76
Storage and insurance	10.00	10.00
Repairs (parts) on harvester	10.73	3.00
Time of mechanics for making repairs	17.66	
Use of auto, 400 miles at 5 cents	20.00	
Man labor, 30 cents per hour	301.50	227.40
Horse labor, 15 cents per hour	144.45	137.70
Gasoline, 15 cents per gallon	51.60	58.05
Grease, 20 cents per pound	11.00	11.00
Oil, 60 cents per gallon	11.14	11.14
Overhead costs of 3-plow tractor, 66 cents per hour	56.76	54.12
Overhead costs of 2-plow tractor, 47 cents per hour	40.42	38.54
Total costs	775.61*	682.10
Total costs per ton	1.50*	1.10
Average cost per ton for the two years	$1.29**	
Man-hours per ton	1.95*	1.23
Horse-hours per ton	1.87*	1.49

*This does not include any charge for the approximately 40 tons of ensilage corn missed by the harvester. Some of this was gathered so that the ground could be prepared for the sowing of wheat. To do this required approximately 15 man-hours and 6 horse-hours per ton. Under most farm conditions this would not be done but the remaining corn would be salvaged by turning livestock in the field.

**This total cost per ton is almost identical with the average figure for 67 farms using ensilage harvesters and 47 farms using stationary cutters as given in Illinois Agr. Exp. Sta. Bulletin 373.

two years would then be interest on the average value during the lifetime of the machine.

* * * * *

COMPARISON OF COST OF ENSILING CORN WITH FIELD HARVESTER AND CORN BINDER

In comparing costs in the use of the corn binder and of the field ensilage harvester, the figures obtained on the college farms could not be used in their entirety because the conditions under which the two machines worked were not similar. Corn was cut by hand and with the corn binder to make room for turning and passage ways for the harvester. This corn was ensiled with the stationary outfit. Aside from this the corn binder was used in smaller fields and closer to the silos. Also the binder was nearly worn out.

After allowing for the different conditions of use, it was agreed that there was practically no difference between the corn binder and the field ensilage harvester, either in the amount of corn cut per hour while in operation or in the horse labor required. The harvester saved the work of the man on the corn binder and of the four men who put the bundles of corn on the wagons for the time required to fill the silos. This amounted to approximately ¾ man-hour per ton. To offset this, there was a difference in interest, depreciation, repairs, gasoline consumption, and size of tractor required in favor of the cheaper outfit. The value of the extra gasoline, oil, tractor hire, and grease used by the harvester minus the cost of the twine used by the binder was 2.9 cents per ton.

There was also another difference. In case of a breakdown or stop with the corn binder the time of only two men was lost, while the repair was made. The other men could continue work. If there were not enough corn cut ahead to keep them busy, they could cut by hand. In the case of the ensilage harvester, silo filling would have to cease.

In making a charge for this no delay of less than ½ h was counted nor was any account taken of the part of delays extending beyond the noon or evening following their occurrence, as it was assumed that the employer could then use his men at other work or send them home without loss to him. In 1931 seven delays with the harvester of from ½ to 4 h stopped silo filling for a total of 12½ h, causing a loss of 103 man-hours and 103 horse-hours. If there had been similar delays with a corn binder, the lost time would have involved only the man on the corn binder and the man on the tractor hauling it, or a total of 25 man-hours. The other men and the teams could have continued work until noon or evening ensiling what corn was already cut, or cutting by hand if necessary. Consequently, there would be a difference of 78 man-hours and 103 horse-hours in favor of the corn binder. Since in 1931 conditions were unusually bad and in 1932 there were no such delays, only one-half of this wasted time (that is, the average wasted time for the two years) was listed with the annual overhead costs of the harvester.

Comparison of Annual Overhead Costs of Tractor-Drawn Corn Binder and Field Ensilage Harvester

	Corn binder	Ensilage Harvester (average of 1931 and 1932)
(Annual use for 550 to 600 tons of silage assumed)		
Depreciation of binder and harvester, 12½ per cent of cost	$25.00	$65.00
Depreciation of cutter and blower, 6¼ per cent of cost	25.60	14.38
Interest* on binder and harvester	6.75	17.55
Interest on cutter and blower, 2 per cent	13.07	7.33
Repairs to binder and harvester	10.00**	25.66
Repairs to cutter and blower, 2 per cent	8.20	4.60
Storage, insurance, etc.	7.00	10.00
Extra wagon costs for harvester, 10 per cent		5.50
Wasted time (man-hours, 30 cents; horse-hours, 15 cents)	7.50	26.93
	$103.12	$176.95
Excess of overhead costs for field ensilage harvester		$72.83

*Interest was computed on the average value during the estimated life of the machine.

**Repairs to the binder were estimated at 5 per cent of cost of a new binder.

The additional overhead cost would make the field harvester impractical for a small acreage. Inasmuch as the harvester saved ¾ man-hour of labor per ton and used 2.9 c worth more power, it saved 19.6 c per ton on these two items. To offset $72.83 additional overhead cost on the harvester, one would need 372 tons or more of silage to cut annually before the harvester could be used advantageously. This is the figure arrived at when labor is worth 30 c per hour. If good labor for the heavy work of silo filling can be obtained at 20 c per hour, one would need about 620 tons of silage before a harvester would prove more profitable than a binder.

No comparison was made with a horse-drawn binder. If horses were used one man (the man operating the tractor) could be dispensed with. This would reduce the saving of man labor due to the harvester from ¾ man-hour per ton to 3/5 hour.

SUMMARY

There are certain limitations that must be reckoned with in considering the practical possibilities of the field ensilage harvester. Under some circumstances, these are insurmountable, while under other circumstances, they may not be serious. Chief among them are the following:

1. There must be a sufficient acreage of silage corn so that the saving in labor is enough to offset the higher overhead costs of the machine.
2. The topography must be fairly level. A steep hill, although short, might require more power than farm tractors can develop. Grades in the fields, sufficient to make it necessary to rest horses while loading, would also make the use of the machine undesirable.
3. There must be a tractor available capable of pulling the harvester. A three-plow tractor will do this.
4. Where a corn binder is owned or must be purchased

(Continued on page 100)

Results of a Food Refrigeration Study[1]

By W. N. Danner, Jr.[2]

THE agricultural engineering and the home economics divisions of the Georgia State College of Agriculture began a cooperative project[3] in 1931 to determine the best methods of food refrigeration in Georgia homes.

A home study was first made in forty-five homes in Athens and its vicinity to determine what temperatures were being provided for the storing of foods in the refrigerators. Recording thermometers were placed in these refrigerators and left for a period of three days. A record was made of the kind, size, and location of the refrigerator, the location of the thermometer in the refrigerator, and the room temperature. This study was made during August and September, during which months the outside temperature ranged from about 70 to 90 deg F, with an average of 80 deg.

As a result of this home study, it was found that the average storage temperature in the ice refrigerators was approximately 10 deg higher than the average storage temperatures in the electric refrigerators. Incidentally, both types were found to be above the most efficient temperatures for food storage, as determined by the controlled laboratory tests referred to later in this paper.

A special constant-temperature room was built for conducting the laboratory work of this project. The walls consisted of 8-in tile with 3-in corkboard asphalted to it, and plastered on both sides. The floor had 3-in corkboard asphalted to 4-in tile and an inch of cement mortar over the corkboard.

The following refrigerators were used in this test:

No 8 Frigidaire (10 cu ft gross storage), No 6 General Electric (7.5 cu ft gross storage), No 8 de luxe model Kelvinator (10 cu ft gross storage), No 5 Electrolux (5.7 cu ft of gross storage), 100-lb Bohn ice refrigerator (12 cu ft gross storage) and 75-lb Progress ice refrigerator 8.8 cu ft gross storage).

LABORATORY TESTS

Tests were conducted with the refrigerator temperature at 5-deg intervals from 35 to 50 deg F, inclusive, with the room temperature at each 10-deg interval from 70 to 110 deg F, inclusive. The Kelvinator and ice refrigerators were run once for each room temperature. As a de luxe model Kelvinator was used it had no outside cold control, and was set for approximately 40 deg refrigerating temperature.

One test was run at 55 deg F refrigerator temperature, and since all of the foods spoiled, it was considered unnecessary to run any more tests at this temperature.

Milk, pork chops, canned peas, lettuce, and fresh tomatoes were stored in each refrigerator for a period of five days for each of these tests. All the foods were stored in open sterilized dishes with the exception of the milk, which was put in sterilized bottles having ground glass stoppers.

A bacterial count was made of each bottle of milk in each refrigerator at the beginning and end of each five-day period, and of each three-day period of storage. Bacterial counts were made in conformity with the plate-count method of the standard methods recommended by the American Public Health Association. Standard Medium with a ph of 6.6 was used.

An acidity test was made of each bottle of milk in each refrigerator at the beginning and end of each five-day period, and of each three-day period of storage. Mann's method of making acidity tests was used. Duplicate tests were made on each sample to check within 0.01 per cent.

All other foods were weighed immediately before and immediately after being stored and were also judged on their appearance and odor after having been stored.

Records were kept of the fuel consumption of each refrigerator for each five-day period of storage, and the fuel consumption per cubic feet of storage space per month was computed from these records.

To determine the most efficient storage temperature, it was necessary to interpret the fuel consumption data along with that showing percentage loss in weight.

A study of the milk shows that at temperatures, ranging from 40 to 45 deg F, the bacteria multiplied about one-tenth as rapidly as in the range between 45 and 50 deg. The per cent acidity shows the same rate for the five-day storage period and is considerably less for the three-day storage period. From this it can be seen that a household refrigerator should cool milk at a temperature below 45 deg F. This temperature is rather difficult to obtain in an ice-cooled refrigerator.

The pork chops had a very small variation in per cent loss in weight for the different temperature ranges, but in all cases they spoiled if stored above 45 deg F. Hence, the storage temperature for pork chops corresponds with that of milk.

Our data show that the tomatoes had only a slight variation in per cent loss in weight for the different storage temperatures. However, the peas, lettuce, and peaches showed a greater variation, and in all cases they had a decided increase in per cent loss in weight when stored above 45 deg F.

The vegetables had a smaller per cent loss in weight when stored in an ice refrigerator than in either the electric or gas refrigerator at the same temperature. This is due to a higher moisture content in the ice refrigerators.

From our data we concluded that a 35 deg F storage temperature is too expensive from the standpoint of energy consumption.

Therefore, from these observations it is concluded that from 40 to 45 deg F is the best and most efficient temperature to store foods in the home. Hence, the storage temperature for the remainder of the project was approximately 42 deg F.

Effect of Defrosting. Two series of tests of five days each were conducted, the first with practically no frost on the cooling unit, and the second with a very thick frost on the cooling unit. The foods stored consisted of canned peas, canned peaches, fresh tomatoes, lettuce and pork chops, all of which were stored in open dishes.

All of the foods had a good appearance and odor at the end of the test when stored with no frost on the cooling unit. With the exception of the pork chops, every food in one or more instances had begun to spoil when stored with a thick frost on the cooling unit.

There was an average increase of 12 per cent in current consumption with thick frost on the cooling unit.

Following is a comparison of the average percentage loss in weight of foods and current consumption without and with frost on the cooling unit of all refrigerators:

Foods	No Frost* Per cent loss in weight	Thick Frost** Per cent loss in weight
Tomatoes	0.7	0.9
Lettuce	16.1	15.3
Meat	16.9	21.9
Peas	23.9	25.5
Peaches	50.4	54.0

*Current consumption, 6.7 kwh per cu ft per mo
**Current consumption, 7.5 kwh per cu ft per mo

[1]Paper presented at a meeting of the Southern Section of the American Society of Agricultural Engineers held at New Orleans, Louisiana, February 1933.

[2]Assistant professor of agricultural engineering, Georgia State College of Agriculture. Jun. A.S.A.E.

[3]Project A.E. 10 "Temperature Studies on Household Refrigeration." W. N. Danner, Jr., agricultural engineer, and B. Gartrell Danner, home economist.

It is apparent that thick frost on the cooling unit is not only injurious to the foods that are stored but is also the cause of a large increase in current consumption.

Best Methods of Storing Foods. Lettuce, cut cabbage, ground meat, cheese, and cooked apples were stored in the Frigidaire, General Electric, Kelvinator, 100-lb ice refrigerator, and the 75-lb ice refrigerator in (1) covered dishes, (2) waxed paper, (3) open dishes, and (4) special vegetable pans.

Records were kept of fuel consumption, the appearance after having been stored, and the per cent loss in weight during storage.

There was very little difference in the appearance and per cent loss in weight of lettuce and cut cabbage stored in covered dishes, in waxed paper, and in special vegetable pans. From the standpoint of convenience, it will probably be easier to use the special vegetable pan, but all refrigerators are not equipped with such, and the covered dish and waxed paper will give just as good results. Lettuce and cabbage stored open in the refrigerator not only lost a large percentage in weight but became discolored and shriveled.

Ground meat spoiled when stored practically airtight. Hence, it seems necessary to store it open, but even then it loses quite a bit of weight and becomes hard on top if stored as long as five days.

Cheese kept very well stored in a covered dish or in waxed paper, but became hard, dry, and discolored when stored in an open dish. Cooked apples kept very well when stored in covered dishes, but when stored in open dishes they became very dry.

Effect of Hot Foods in Refrigerator. The foods used in these tests were applesauce and tea. The Frigidaire, General Electric, Kelvinator, 100-lb ice refrigerator, and 75-lb ice refrigerator were used. A quart of tea at 70 deg F and the same amount of applesauce at 75 deg F were put in each refrigerator eight times during a period of five days.

Temperature records were kept with recording thermometers and both current and ice consumption records made. The test was then repeated putting the foods in at a temperature of 180 deg F.

When the foods at a temperature of 180 deg F were stored in the electric refrigerators, there was a decided rise in temperature each time the foods were put in.

The ice refrigerators had only a very small rise in temperature when the foods at a temperature of 70 to 75 deg were put in, and a much greater rise when the hot foods were put in. There was a decided temperature drop in the refrigerator when the ice was put in.

There was a 13-per cent increase in kilowatt-hours used and 7 per cent increase in pounds of ice used per cubic foot of storage space per month when hot foods were stored. Hot foods also caused frost to collect more quickly on the freezing units. So it would seem that it is best to let foods cool to approximately room temperature before putting them in the refrigerator.

Several tests were conducted, using the electric refrigerators, to determine the effect on temperature and current consumption when freezing ice cubes and desserts. Very little current was needed in excess of that required for refrigeration when freezing moderate amounts of ice and desserts.

CONCLUSIONS

This refrigeration study indicates that

1. The average home food storage temperature is 55½ deg F when ice is used and 45 deg when electricity is used.

2. A range of 40 to 45 deg F appears to be the most efficient food storage temperature for the home.

3. The foods lost less per cent of weight in the ice refrigerators than in the electric refrigerators, when stored at the same temperature.

4. The foods in the gas refrigerator lost, in most instances, a greater per cent in weight at corresponding temperatures than in the electric refrigerator.

5. For a constant room temperature the energy consumption of the electric refrigerators varies inversely as the storage temperature.

6. For a constant storage temperature the energy and ice consumption of the refrigerators increase with an increase in room temperature.

7. The rate of increase in energy consumption is greatest for high room-refrigerator temperature differentials and least for low temperature differentials.

8. The temperature in the ice refrigerators increased with an increase in room temperature.

9. The greatest possible room-refrigerator temperature differential was from 70 to 75 deg F.

10. A heavy frost on the cooling unit of electric refrigerators increased the energy consumption approximately 12 per cent.

11. Foods spoiled more readily with a heavy frost on the cooling unit.

12. Lettuce or cabbage should be stored either in a special vegetable pan, covered dish, or waxed paper, and never open in the refrigerator.

13. Cheese should be stored either in a covered dish or wax paper.

14. Cooked apples should always be stored in covered dishes.

15. Meat should neither be stored in airtight containers, nor any longer than necessary.

16. The storage of hot foods increased the energy and ice consumption, raised the refrigeration temperature, and increased the amount of frost on the cooling unit.

17. Foods should be cooled to approximately room temperature before being stored in the refrigerator.

18. Freezing ice cubes and ice cream requires very little current in excess of the amount required for refrigeration.

The Field Ensilage Harvester

(Continued from page 98)

anyhow, the outlay for a harvester can not be justified, unless there is work enough for two outfits.

5. Since the machine is not adapted to handling corn cut by hand, there must be a practical method to provide room for turning at the ends and for passageways through the field. The best method of doing this will vary with individual circumstances.

Other disadvantages of the field ensilage harvester are:

(a) If the corn is down badly, the machine leaves some in the field, as does a corn binder.

(b) In the case of a light crop, it may take too long to cut a load. Unlike the corn binder, it cannot be run at night or at meal time to make up for this, unless the entire crew works also.

(c) In case of a breakdown, silo filling stops; whereas, if a corn binder is used, it may be several hours ahead of the cutter and be repaired while silo filling continues.

(d) It is more exacting as to size of crew necessary to operate.

(e) A greater percentage of the costs are cash costs.

The advantages of the field ensilage harvester are as follows:

1. It saves man labor. Five less men are required than when cutting with the corn binder. This may be more of a saving than the wages would indicate, for often men are difficult to secure at silo filling time.

2. The hard work of silo filling is largely eliminated. Old men or boys can be used to good advantage with the harvester driving teams. It is needless to say that the crew appreciates the easier work.

Assuming that the topography is suitable and that corn is ensiled in large quantity, the most important factor in determining the practicability of the machine is the wage rate. High wages favor its use while cheap labor would tend to favor the older method.

Spontaneous Heating and Ignition of Hay[1]

By Harry E. Roethe[2]

THE SPONTANEOUS heating of hay in storage has aroused the interest of man from the time when the primitive male first attempted to store grass in his prehistoric cave. It has been observed among all races of mankind, that hay when piled in large masses frequently heats spontaneously, and in certain cases actually catches fire.

The spontaneous heating and ignition of agricultural products, especially stored hay, causes enormous losses each year. It has been conservatively estimated that spontaneous ignition of hay causes an annual loss of $20,000,000 in farm property in the United States. In addition to this fire loss there is the loss from deterioration and spoilage of hay resulting from abnormal self-heating, even when not followed by fire. This loss from spoilage is undoubtedly several times greater than that from fire.

Data compiled by the Bureau of Chemistry and Soils (U. S. Department of Agriculture) from surveys show that apparently the leguminous hays are most subject to spontaneous heating and ignition, although fires of this nature also occur in other hays and even in straw. It also appears that barn storage is more conducive to the severe self-heating of hay than storage in stacks. Spontaneous ignition occurs in chopped hay as well as in long hay. There is reason to believe, however, that because of the greater density of the product, which makes it more difficult for air (oxygen) to penetrate to the hot pockets inside the mass, a fire caused by spontaneous heating is not as likely to occur in chopped hay as in long hay, other factors being equal. Furthermore, because of this greater density, which would retard or decrease aeration of the mass, it seems logical to conclude that chopped hay would be more subject to the formation of hot pockets or heating areas than long hay, other factors again being equal.

Excessive spontaneous heating may occur in artificially cured or dehydrated hay if control of the moisture content of the finished product is poor. There are records of cases of excessive heating followed by ignition where relatively small quantities of chopped hay came from the drier with a high moisture content, although the remainder of the hay had been well dried. Hot spots developed in the hay in storage, the heating apparently occurring in the areas occupied by the wet hay. At some of these locations charring resulted, and at others fire broke out.

This survey also has shown that a fire is most likely to occur in heating hay from two to six weeks after the hay has been placed in storage. In the cases studied 75 per cent of these fires took place from one to eight weeks after the hay had been stored. Eighty per cent of the fires occurred during the months of June (17 per cent), July (26 per cent), and August (37 per cent).

Undercured or moist hay stored in large piles and hay which has become wet subsequent to storage as a result of rain coming through a leaky roof, for example, will heat spontaneously. This heating may continue until the ignition temperature of the hay is reached. It is generally agreed that several agents contribute to the initial stages of heating, such as the respiration of plant tissue cells and the action of microorganisms. These cannot of themselves produce temperatures sufficiently high to cause the ignition of hay, however, since at temperatures of 80 deg C (176 deg F) to 100 deg C (212 deg F) most enzymes, bacteria, and fungi have become inactive. The ignition temperature of an alfalfa hay which had been in storage is reported by Dr. E. J. Hoffman, Bureau of Chemistry and Soils, to be about 200 deg C (392 deg F). The question naturally arises, "What is it that causes the elevation in temperature to the point of ignition of the hay?" This is a puzzle which has bothered scientists for many years, and numerous theories have been proposed to explain the phenomenon. Dr. C. A. Browne, assistant chief, Bureau of Chemistry and Soils, believes there may be produced unstable compounds which are rapidly oxidized upon the access of air with so great an evolution of heat that the temperature is quickly raised to the point of ignition of the hay.

Two of the important factors which play a fundamental part in the spontaneous heating and ignition of hay in storage are (1) moisture content of the hay and (2) volume and density of the mass. Moisture is an important factor in heat-producing reactions. Volume and density of the mass of hay are important from the standpoint of heat retention and of pressure. High temperatures cannot prevail if the heat is dissipated faster than it is produced. At the same time the mass must not be so dense that it will prevent the slow infiltration of air (oxygen) from the outside to the inside of the mass.

The U. S. Department of Agriculture is studying the spontaneous heating and ignition of hay, both in the laboratory and in large-scale experiments. So far as long alfalfa hay is concerned, the results of this research indicate that:

1. As a safety measure the moisture content of loose hay in storage should not be more than 30 per cent. It is unlikely that hay of this moisture content will heat much beyond the normal sweating stage.

2. Mows of hay of 10 tons and less are not liable to heat to a dangerous degree.

3. Mows of hay unusually wet or green and very densely packed will not ignite spontaneously—there is too great a quantity of water to be evaporated, and no chance for air from the outside to eventually reach the heating area or areas inside the mass. Such hay, however, will undergo fermentation to the extent that it will be unfit for feeding purposes.

4. Cured hay on which dew or rain has fallen and which has been stored without fur-

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[1]A contribution of the Division of Chemical Engineering, Bureau of Chemistry and Soils, U. S. Department of Agriculture. Released for first publication in AGRICULTURAL ENGINEERING.

[2]Engineer, division of chemical engineering, Bureau of Chemistry and Soils, U. S. Department of Agriculture; chairman A.S.A.E. Committee on Fire Prevention and Protection. Mem. A.S.A.E.

ther curing, and cured hay which has become wet subsequent to storage may be subject to severe self-heating and ignition.

5. Laboratory experiments by L. S. Stuart and Dr. L. H. James of the Bureau of Chemistry and Soils have shown that the addition of salt to hay delays microbial growth which may permit curing out of the hay. The addition of salt, however, should not be considered a substitute for sufficient curing of the hay in the field.

Field observations indicate that red clover hay probably can be stored with a moisture content somewhat higher than that of alfalfa, with no corresponding increase in self-heating tendencies.

Because of its apparent greater palatability or the relish with which it is eaten by livestock, "tobacco-brown" hay, or hay which has undergone a more severe fermentation and heating while in storage than ordinary hay, is preferred by many farmers in this country. During the curing-out process in the mow, such hay not only loses much if not all of its natural color and takes on various shades of brown, but it also apparently loses material quantities of nutrients, depending upon the degree of fermentation. Unfortunately the heating may continue beyond the stage desired to produce brown hay, in which case black, heat-burned, or acid-burned hay will be obtained, or charring and ignition may occur. The practice of producing brown hay is one not to be recommended, therefore, except in regions where the amount of sunshine is insufficient for the proper curing of hay by ordinary methods, because of (1) the fire hazard, (2) the possible spoilage of the hay due to abnormal heating (not followed by fire), and (3) the apparent loss of nutrients even though the farmer is successful in controlling the degree of fermentation and heating.

Losses from fire caused by spontaneous ignition of hay as well as losses from hay spoilage resulting from spontaneous heating can be minimized by following these recommendations:

1. Hay should be sufficiently cured, consistent with the production of good quality, before being placed in mows or stacks. A range of 25 to 30 per cent moisture content for long alfalfa and clover hays is suggested. Care should be taken to see that no batch or load of hay goes into storage with a moisture content above 30 per cent, even though the greater bulk of the hay falls within the range of safety.

2. Cured hay upon which rain or dew has fallen should be cured again before being stored.

3. Wetting of cured hay in storage, as from rain through a leaky roof, should be guarded against.

THE STORAGE OF HAY PRESENTS SOME DIFFICULT PROBLEMS

The storage of hay, all or some of which is not sufficiently cured, presents some puzzling and complicated problems. There is yet no conclusive information as to the best practice to be followed in safeguarding against abnormal and dangerous self-heating in such cases. It is frequently recommended that salt (0.5 per cent by weight) be added to damp or undercured hay as it is being placed in storage. The salt should be scattered or sprinkled on the hay as uniformly as possible.

It is the opinion of the author that long hay should be ventilated as freely as possible immediately after it has been placed in the barn, in an effort to carry off as rapidly as possible the heat generated in the mass and to cool the heating area or areas. Limited ventilation may be provided by opened doors and windows, louvers, ventilators on the roof of the barn, and siding of the open, crackboard type. Greater and more direct ventilation may be obtained by special devices, such as a slatted, false bottom placed about 8 inches above the floor of the barn, built-in chutes of open construction placed upright in the mow, through each of which a natural upward movement of air would be provided, and division of the mow into several compartments by means of openwork partitions or studding. The chutes should be 1½ or 2 ft square, spaced not more than 10 ft apart, and each chute should serve a floor area of not more than 100 sq ft. Each compartment should not be more than 12 ft or possibly 14 ft wide with at least two exposed sides (paralleling each other). The false bottom could well be used in conjunction with either the chutes or the compartments, to insure maximum natural aeration.

The proper handling of a mow of long hay which is known to be heating abnormally is of much practical importance. Preservation of a high degree of leafiness and color demands that all handling of alfalfa be done when the hay is in a tough or at least slightly tough condition. Such hay undergoes during storage a certain amount of fermentation or normal "sweating," with the production of temperatures in the mass running probably as high as 45 deg C (113 deg F). If the moisture content of the hay is above that for normally cured hay (between 25 and 30 per cent), the fermentation will be more severe, higher temperatures may prevail, and the resulting hay will range anywhere from what is called "tobacco-brown" hay to severely heat-burned or acid-burned hay, and even charred hay.

KNOWLEDGE OF TEMPERATURE IN THE HAY MOW IMPORTANT

Provision should be made to obtain temperatures prevailing inside the mass of hay so that the degree and progress of heating can be known. If more elaborate equipment is lacking, temperature readings may be obtained in the following manner: Drive a pointed metal rod (about ¾-in in diameter) vertically downward into the hay. Remove it and lower into the hole a thermometer (such as the general laboratory type), by means of a strong cord attached to the upper end. After a few minutes withdraw the thermometer and read quickly. Readings at 2 or 3-ft vertical levels at several different locations should suffice for the preliminary observations. If a pointed pipe (¾ to 1 in outside diameter) is available drive it a few feet down into the hay and lower the thermometer into the point. When the temperature has been recorded, the pipe should be driven to several successive depths, readings being taken in the same manner at each level. Sufficient time (probably 20 minutes) should be allowed for the pipe to reach the same temperature as that of the hay, before final readings are taken. Trial readings should be taken at intervals of several minutes each until the recorded temperature is found to be fairly constant. If several pipes are available, they can be inserted at selected locations and left at the hottest level during the period in which readings are taken.

In most cases the hottest area or areas will be found near the center of the mow. Characteristic wet or damp spots and flues on top of the mow, and the emission of vapor and heat will assist greatly in determining the horizontal location of this area.

When a temperature of 70 deg C (158 deg F) in the hay has been reached, observations should be made at least twice daily, preferably in the morning and late afternoon. When the temperature climbs to 85 deg C (185 deg F), the dictates of caution and safety warrant removal of the hay and stopping of all possible ventilation. While it is true that hay in which such a temperature prevails may range from a deep "tobacco-brown" to a black, severely heat-burned, or acid-burned hay, and if left undisturbed, may cool eventually without further heating, safety first should be the watchword.

A temperature of 100 deg C (212 deg F) is a critical one. It indicates that the hay involved will eventually ignite if left in storage. The hay in a mow in which this temperature is found should be removed as soon as possible, but before this is done a hose line should be run to the barn, or copius supplies of water should be made available for wetting excessively hot hay and for combating a possible fire. This will mean in most cases calling the local fire department and utilizing its services before removing the hay. There is a heating stage beyond 100 deg C and ranging upward to the ignition point where the heating hay should not be uncovered or removed without

(Continued on page 104)

Soil Erosion Control by Terracing

History and Accomplishments

By C. E. Ramser[1]

SOIL EROSION CONTROL is one of the most important problems confronting agriculture today. The loss to farmers from soil erosion is estimated at 200 million dollars annually. Studies of the hillside erosion of farm lands were made by the Division of Drainage Investigations, Office of Experiment Stations (U. S. Department of Agriculture) in 1903 and 1904, and studies of the use of terraces to combat this enormous loss were started in 1914. These studies were continued by that division after it was transferred to the Bureau of Public Roads, and are being conducted at present by the Division of Drainage and Soil Erosion Control in the Bureau of Agricultural Engineering.

As a result of these investigations, instructions based on sound engineering principles relating to the terracing of farm lands were prepared and they are now widely accepted as the basis of terrace design. Later, a similar investigation of methods employed to control and reclaim gullies was made, and engineering principles governing the design and installation of control structures were formulated and published. It is reported by the extension service that over 3,000,000 acres of land were terraced during the year 1931.

Investigations were begun in January 1929 to obtain experimental data relating to erosion problems in order to improve methods and reduce the cost of erosion control. Since that time ten soil erosion experiment farms, containing 140 to 300 acres each, have been established where experiments are being conducted cooperatively by the Bureau of Agricultural Engineering, the Bureau of Chemistry of Soils, and the state agricultural experiment stations. They are located near the following cities, in the order in which they were established: Guthrie, Oklahoma; Temple, Texas; Hays, Kansas; Tyler, Texas; Bethany, Missouri; Statesville, North Carolina; Pullman, Washington; Clarinda, Iowa; LaCrosse, Wisconsin; and Zanesville, Ohio. These farms are in regions representing wide differences in soils, climate, and farming practices.

The objects of the engineering investigations conducted on these farms are (1) to determine the carrying capacity of terraces for the prevention of soil erosion and the conservation of water on agricultural lands for different soils and land slopes, the required carrying capacity depending upon the fall, the vertical spacing, and the length of terrace; (2) to determine the effectiveness of terraces in preventing erosion and conserving moisture by comparison of run-off and soil losses on terraced and unterraced land; (3) to develop the most economical methods of constructing and maintaining terraces under different farming conditions and practices; (4) to determine the best available machinery for building terraces and to design better machinery adapted for this purpose; (5) to study the operation of various types of farm machinery over terraced land with a view to recommending changes in design to improve their operation, and (6) to improve the design and construction and to reduce the cost of various type of check and soil-saving dams to control erosion in road ditches, gullies, and at the ends of terraces.

At some of the soil erosion stations sufficient information has been obtained to show the effectiveness and value of terraces in reducing soil losses. On the Red Plains Soil Erosion Station near Guthrie, Oklahoma, the record of soil losses during 1931 shows that 43.9 tons of soil per acre were lost from an unterraced area as compared with 1.25 tons per acre from a level-terraced area, both areas being planted to cowpeas and having somewhat similar cover crops. That terraces are effective in controlling erosion on the experimental farm at Hays, Kansas, is evidenced by the fact that, while terraced land with slope of 8 per cent planted to kaffir lost less than 2 tons of soil per acre in a rain of 2½ in, the loss from unterraced land of 5 per cent slope similarly cropped was 14 tons per acre, or over seven times as great. The value of terraces in reducing erosion losses on the farm at Bethany, Missouri, is apparent from the record of soil losses from clean-cultivated land planted to corn. During a 12-month period 2.64 tons of soil per acre were lost from a level-terraced area as compared with 104 tons per acre from an unterraced check plot. On the experimental farm at Pullman, Washington, where moisture conservation is also a problem, 75 per cent of rainfall and more than 7 tons of soil per acre were lost from an unterraced field in winter wheat as compared with 2½ to 10 per cent of the rainfall and 0.02 to 0.09 ton of soil per acre lost from a terraced field during January to March 1932.

At Guthrie on terraced areas otherwise comparable, soil and water losses from cultivated land severely eroded prior to terrace construction were twice as great as from land recently broken out. The cost of building terraces on the badly eroded and gullied land was more than six times as great as that of building terraces on the newly broken land where no gullies existed. The economy of terracing farm lands immediately after they are first

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Tremendous strides have been made, in the brief period of four years (since 1929), in bringing soil erosion control through terracing to the front as a major agricultural-engineering activity. The loss of valuable resources of agricultural lands through soil erosion represents perhaps our greatest national waste of natural resources. Yet it is a waste which, in a large measure, can be checked, as has been effectively demonstrated by the remarkable accomplishments of a relatively small group of agricultural engineers, most of them in the employ of federal and state governments. This important work, in behalf of agriculture, merits much wider recognition and much more generous support than it has yet received

broken, rather than waiting until gullying starts, is further emphasized by the fact that the yield of lint cotton on the new land was 34 per cent greater than on the eroded area.

Outstanding among the results obtained on the design of terraces is the information collected on the farm at Tyler, Texas, which supports the recommendations made by the Bureau of Agricultural Engineering in 1916 that a terrace with a variable grade is more effective in controlling erosion than a terrace with uniform grade. Measurements of the discharge from two terraces 700 ft long, one with uniform fall of 6 in per 100 ft and the other with grade varying from 0 to 6 in per 100 ft, showed that two-thirds more water and one-third more soil were removed from the former during the year 1931. At Bethany, Missouri, the relative efficiency of variable and uniform graded terraces was indicated by an experiment consisting of two terraces about 1,200 ft long, one with a uniform fall of 4 in per 100 ft and the other with fall varying from 0 to 4 in per 100 ft. Nearly twice as much soil was lost from the uniform-graded as from the variable-graded terraces.

The effect of fall or grade of terrace upon soil losses was demonstrated in experiments at Guthrie, Tyler, and Bethany. At Guthrie, for terraces of equal length and vertical spacing where soil type and ground slopes were alike, soil losses were found to increase with increase in grade of the terrace. While level terraces permitted a loss of only 1.25 tons per acre, the loss with terraces having 6 in fall per 100 ft was 5.46 tons per acre, or over four times as great as with level terraces. The effect of terrace grade upon the amount of soil carried away as found at Guthrie was corroborated by experiments at Tyler, Texas, where the soil loss from a terrace 700 ft long with a 6-in grade was one-third greater than the soil loss from a terrace of the same length with only a 3-in grade. At Bethany, Missouri, the terrace most efficient in conserving soil was level, 1,200 ft long, with 5-ft vertical spacing, located on a 12 per cent land slope. The soil loss from this terrace was but 28 per cent of that which occurred from a similar terrace having a fall of 6 in per 100 ft. However, there was considerable damage to crop due to water standing in the terrace channel, which suggests that the use of level terraces in this region may be limited.

Results of an experiment at Guthrie show that soil losses are greater for the wider spacings between terraces. With terraces 700 ft long having a uniform grade of 4 in per 100 ft, the average soil losses were 2.74 tons per acre for terraces with 2-ft vertical spacing, 3.96 tons per acre for terraces with 3½-ft spacing, and 4.98 tons per acre for terraces with a 5-ft spacing.

That short terraces are somewhat more effective than long terraces in controlling soil erosion was indicated by the results of an experiment at Tyler, Texas. About 20 per cent more soil was lost from two terraces 1,700 ft long with spacings of 4 and 5 ft than from two terraces 700 ft long with the same spacings.

The construction of terraces with closed ends designed to prevent all surface run-off, was found to be impractical under soil conditions in the Red Plains Region at the Guthrie station because of the necessary height of terrace or alternative small vertical spacing, the hindrance to farm operations by wet channels, and the reduction in crop yields due to drowning of the crop in the terrace channel. Similar results were obtained in the Blackland region of Texas at the Temple station. The slow percolation of the water into the soil is responsible for the impracticability of such terraces. The results of this experiment are contrary to those obtained in western Oklahoma and southwestern Texas where the rainfall is light and the soil of open texture, and increases in wheat yields of 25 to 40 per cent have been recorded on land where all the rainfall was retained by terracing.

The results given in this article on soil erosion control are by no means conclusive, but the data so far collected clearly indicate that terraces well designed and well constructed are very effective in reducing the rate of soil erosion. Much additional information was collected on the farms at Guthrie, Temple, Tyler, Hays, Pullman, and Bethany during the year 1932. On the other farms, except at Zanesville, practically all of the equipment has been installed and complete data will be collected for the year 1933. Most of the experimental equipment will be installed at Zanesville during the first half of the year 1933, and records will be obtained during the latter half of the year.

Spontaneous Heating and Ignition of Hay

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first being thoroughly wet with water, otherwise when exposed to the air it will burst into flame. In removing hay which has reached this advanced stage of heating, there are several other precautions which should be observed:

1. Place planks over the surface of the mow, especially at the center. This will insure sound footing in case the central portion has charred and sunk.

2. Avoid inhaling the noxious fumes and gases from the hot spots and pockets. Provide as much fresh air as possible; arrange for the inside work to be done in frequent shifts.

3. Transport the hay removed to a safe distance from the structure, preferably to an open field, so that in case this hay later bursts into flame the barn or other buildings will not catch fire.

In view of the prominent, if not the leading role hay plays in barn fires, both because of its flammability and of its susceptibility to spontaneous heating and ignition, it is surprising that more serious and extensive consideration has not been given to the storage of hay in a structure separate and apart from the barn for housing livestock. The modern dairy barn, with most of its space devoted to holding bulky, long hay, represents a considerable investment, and the risk of a disastrous fire is great because of the hazardous material stored therein.

If the hay and the livestock were placed in individual structures separated by a reasonable distance, the potential loss from fire would be greatly decreased. Furthermore, a saving in building cost, at least in new structures, might result because of the simplified construction which could be used. The need for safeguarding farm buildings against fire and for reducing fire losses would seem to warrant such a departure from the present and long-accepted practice of housing hay and livestock under the same roof. At least it would appear that the possibilities of the separate storage of hay should be given careful study.

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Photoelectric Method of Determining Chalkiness of Rice

By George P. Bodnar[1]

THE READERS of this report may appreciate the value of any method of determining chalkiness of rice, if some explanation is given as to why it should be of importance to anyone.

Chalkiness of rice is one of the principal factors that affect its value both from a miller's and a consumer's standpoint. Studies of the milling process indicate that about one-third the weight of the chalky kernels, as they occur in the brown rice state just before milling, go principally into a by-product known commercially as "rice polish," and to a lesser degree into a number of other by-products. These practically always sell for less than milled whole rice which forms the principal product of milling. Chalky rices are therefore not worth as much to millers as those that do not have this defect.

In addition to this, chalkiness is objectionable from a consumer's standpoint because chalky kernels have a strong tendency to make the cooked product pasty. In general, the clear, crystalline type of rice is much more desirable, as the kernels of this kind are more apt to remain separate and thereby result in a more satisfactory cooked product.

The proper determination of chalkiness is therefore of importance in rice grading, because it assists in establishing the value of any lot of rice in comparison with other rices. It is essential that inspectors determine this defect in rice on the same basis of interpretation, as only in this way can chalkiness have a common meaning necessary in the trade for buying and selling operations.

At the present time chalkiness may be said to be determined principally by visual judgment as to opacity of the kernels, but color effects and reflection of light from the rice probably have some influence in the classification of rice into the groups "chalky" and "not chalky."

The photoelectric cell method of analysis described in this report offers a means of providing a definite line between chalky and non-chalky kernels, after the line or dividing point has once been established by those in authority on grading matters.

The principal equipment used in the determination of chalkiness of rice consisted of a photronic photoelectric cell, a microammeter, a low-voltage a-c voltmeter, an electric voltage transformer, a carbon disk rheostat, and a combined light source and light-condensing unit designed for certain types of Mazda lamps.

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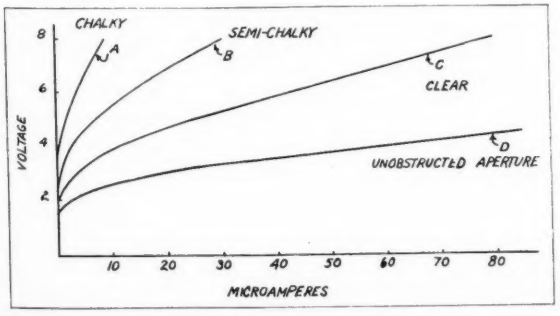

These curves show the relative chalkiness of three types of rice kernels as determined by the photoelectric method

The hook-up consisted of two simple electric circuits. The photoelectric cell and microammeter were connected in series to form the circuit by which the degree of chalkiness of the rice was measured. The controlled light circuit consisted of the transformer, voltmeter, rheostat, and light source and light-condensing unit.

In determining the characteristics of the rice, the kernels were placed over a suitable aperture in an opaque tablet with the photoelectric cell under the aperture, and the light source above the aperture. The highly concentrated beam of light was focused on the rice, and the electrical response of the cell to the diffused light issuing from the opposite side of the rice was taken as a measure of the opacity or chalkiness.

In a series of tests on a sample of brown rice, the kernels were classified photoelectrically into fifty different groups as regards opacity. The shading between any two adjacent groups was so fine that it was difficult to distinguish visually any difference between them. When the fifty groups were merged into ten, by combining adjacent groups, the differences in adjacent groups were more readily noted by the eye.

The results of some of the tests on rices with different degrees of opacity are shown in the accompanying curves. Curves A, B, and C show the relative chalkiness of three types of brown rice kernels designated, respectively, as "chalky," "semi-chalky," and "clear." Curve D shows the response of the photoelectric cell to the direct rays of light through the unobstructed aperture over which kernels of rice were placed during a test, and is drawn in the chart primarily to give a base for comparing the relative opacity of any objects placed over the aperture. This curve may also serve as a means of standardizing similar testing units.

Curve A refers to a type of kernel that is practically opaque, and is of the kind considered chalky without question under present interpretations for this factor in the grading of rice under government rice standards. Curve B represents a semi-chalky kernel, somewhat cloudy in appearance, but not of the type that would be designated as chalky. Curve C represents an ordinary clear crystalline kernel of the type considerably beyond the point at which kernels are classified as chalky. Other types of kernels could be found which would have characteristic curves in the entire range of photoelectric cell response from O to 90 μa (microamperes), as might be shown for a light intensity corresponding to 7 volts.

The dividing point between kernels that are chalky or not chalky, in regard to rice grading interpretations, would probably be represented by a kernel, the response curve of which would correspond to one passing through a point on the chart represented by 13 μa at 7 volts. Such a dividing point or curve, when once established by agreement, would serve the useful purpose of maintaining a constant interpretation for rice graders working at different inspection offices, as it would not be a difficult matter to standardize any number of similar units of this type.

The curves shown represent tests made by the use of a 12-cp lamp. Our test data show that the ratio of the photoelectric cell responses for the rice kernels increases as the voltage applied to the light source is decreased. There is also a strong indication that a 15-cp lamp is more desirable than a 12-cp lamp, since the ratio of the responses for the former are considerably greater than for the latter. The difference in the response ratios is apparently due to the changed character of the light resulting from different filament temperatures.

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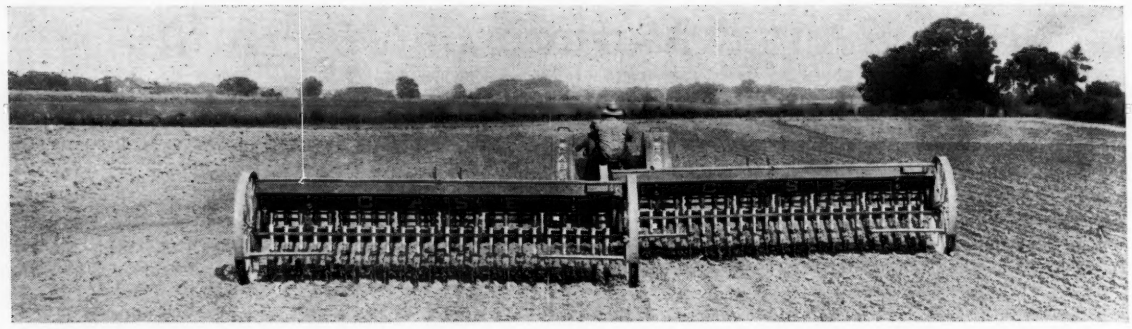

Drilling Powdered Agricultural Limestone[1]

By Wm. A. Albrecht[2] and M. M. Jones[3]

RECENT ADDITIONS to our knowledge of sour soils and of the requirements for successfully growing legumes, indicate that the practice of applying two to three tons of coarsely ground limestone per acre in order to grow certain legume crops bids fair to undergo modification. The well-recognized necessity of liming the soil long in advance of seeding the legume crop is evidence of the sluggishness with which the common agricultural limestone becomes effective. Though relatively insoluble, limestone becomes much more soluble when extremely finely divided. The wider recognition of this fact and the fuller understanding of the functions of limestone in growing legumes are contributing to the impending changes in our liming practice.

It has been recently emphasized that one of the beneficial effects of liming is due to the fact that it supplies the element calcium. Sour soils present a problem not only because of their sourness, but also because of their deficiency in this plant nutrient. This suggests that the lime of the Romans and other ancient agricultural nations may well be called the "forgotten fertilizer." Laboratory studies and field trials suggest the fitness of this newer cognomen, when they demonstrate that 300 lb of finely ground limestone, drilled with the legume at seeding time, is enough to establish red clover, sweet clover, and other lime-loving plants on soils giving tests of 2 to 3-ton lime requirement. Farm trials in cooperation with the Missouri Agricultural Experiment Station, dating from 1926 and in gradually increasing number, suggest the wisdom of giving consideration to finely ground limestone as a fertilizer as well as a soil-sweetening agency.

Trials of limestone of different fineness have always indicated that the extremely fine material is the most important part of the limestone. Early experimental data by the Pennsylvania Agricultural Experiment Station and others following have pointed out that only when limestone is ground finely enough to pass a hundred-mesh sieve, does its effectiveness approach that of the soluble hydrated lime or quick lime. During the early development of the agricultural limestone market, the product offered was of widely varying fineness, for the problems of crushing the stone prohibited much else. It was a by-product. Now science points to the need for a specially prepared material whose effectiveness demands that is be very finely ground.

At present with newer types of stone-crushing machinery which can produce at low cost a limestone ground finely enough to pass a hundred-mesh sieve, and with an entire rearrangement of our economic household in progress, we may well contemplate changes in our liming practice. We may well consider this powdered limestone ground finely enough for most of it to pass a hundred-mesh sieve as the standard product for general use. Its economy is an especially weighty argument for its adoption, since its rates of application are low enough to cut the cost of material to one-half, and the amount handled to one-tenth. Savings in cost of transportation, the convenience of handling a bagged product, and the reduction of the labor of application to a one-man basis instead of a community affair, will direct attention to this newer practice of using the powdered or hundred-mesh limestone.

The powdered limestone must be drilled into the soil. The old methods of spreading limestone broadcast will not suffice. By drilling it, certain areas within the soil are given a concentrated application from which the plant may take its supply of calcium, while adjacent soil areas are not subjected to the radical changes in chemical and biological conditions that would be created by complete neutralization of acidity.

The fertilizer drill presents itself as the logical machine for drilling this fine limestone, and wherever it is available its use is recommended. The scarcity of fertilizer drills in some sections of the country raises the question "Why not drill it with an ordinary grain drill?" The problem of distributing limestone powdered finely enough to pass a hundred-mesh sieve has recently been given some attention in the hope of learning something about its drillability, and the possibility of drilling it with a regular grain drill, as well as the fertilizer drill. The tests reported in this paper indicate that the ordinary grain drill may help solve the distribution problem created by the change from coarsely to finely ground limestone in agricultural practice.

A test was run on the fertilizer distributing part of a superior combined grain and fertilizer drill equipped with the finger or star-wheel type of fertilizer feed. The stone, furnished by the Columbia Quarry Company and ground by a crusher using air draft to separate the fine material,

Table I. Fineness of Powdered Limestone Used

Mesh of test screen	Per cent caught on test screen	Per cent passing through test screen
40	2.0	98.0
60	0.3	97.3
80	1.1	96.6
100	1.6	95.0
200	16.8	78.2
300	46.2	32.0
Through	32.1	

[1]Contribution from the Departments of Soils and Agricultural Engineering, Missouri Agricultural Experiment Station, Journal Series No. 353.

[2]Professor of soils, University of Missouri.

[3]Associate professor of agricultural engineering, University of Missouri. Mem. A.S.A.E.

Table II. Rates of Delivery of Hundred-Mesh Limestone by Different Drills

Superior Drill (Fertilizer Side)*					McCormick-Deering Drill (Grain Side)**		Superior Drill (Grain Side***		
					Limestone rate, lb				
Fertilizer gate opening	Fertilizer rate, lb	Limestone rate, lb	Oats rate pecks	Oats rate lb	Throats open	Throats closed	Gear	Oats rate, quarts, per acre	Limestone, lb per acre
3	115	86	4	32	106	116	3	81	192
5	200	163	6	48	182	200	5	108	217
7	300	233	8	64	225	245	9	162	288
9	400	284	10	80	242	329	13	216	316
12	490	361	12	96	242	354			
15	550	390	14	112	266	371			

*Gear 6.
**Fluted-roll, force-feed type. Agitator in grain box.
***Internal double-run, force-feed type. Set for oats. Homemade agitator in grain box.

had the sieve analysis as given in Table I. The method of testing consisted in filling the fertilizer hopper with the powdered stone, hauling the drill with a tractor for a distance equivalent to one-tenth acre, collecting the stone delivered by each delivery opening in a separate container attached just below the drill box, weighing this, and making calculations on the acre basis. The distributing fingers were set at the high speed (Gear 6), and tests run with different gate openings. The results are shown in Table II, which compares the amount of stone delivered to the amounts of fertilizer that would be delivered according to the sowing table furnished with the drill. The weight of stone delivered in the test varied from 70 to 81 per cent, or an average of 75 per cent of that given in the fertilizer sowing table for the different gate settings. It should be borne in mind, however, that the sowing tables for fertilizer furnished with a drill, can be only approximate at best as different fertilizers vary considerably in weight and drillability. In drilling finely ground limestone through a drill, the rate of application can be determined approximately by noting the acreage covered, as indicated by the drill surveyor, while a known amount of material is drilled.

Attempts were made to drill fine limestone through ordinary grain drills, both of the internal double-run type and of the fluted-roll type of force feed. It was found that this fine, fluffy material would not feed through. Tests were next run on a McCormick-Deering drill equipped with agitators. The drill was of the fluted-roll, force-feed type, and the agitator was of the double-rod type, with three-finger spider stirrers on the lower rod and with two-arm paddle stirrers on the upper rod. Tests were run with the throats beneath the fluted rolls open, and with them closed. The results are shown in Table II. The tests indicate that this drill can be easily made to deliver 200 to 350 lb of this powdery material by setting it the same as for 6 to 12 pecks of oats per acre.

Since it would be difficult to get agitators for some of the older grain drills, a homemade agitator was made and tested in a Superior grain drill, this particular drill being equipped with the internal double-run type of force feed. The agitator was made essentially as follows: A one-inch gas pipe was run lengthwise on top of the drill hopper and mounted in improvised wood bearings. The outer end of this pipe was equipped with a crank so that the pipe could be oscillated back and forth in its bearings. Vertical arms were attached to this pipe and allowed to project downward beside each of the drill runs in the bottom of the hopper. The first design of this agitator failed to work because these vertical arms did not work in close enough proximity to the wheels which carry the seed through the runs.

During the test, the agitator was worked back and forth by hand twice for each revolution of the ground wheels of the drill. Very little effort is required to operate the agitator, and doubtless wooden blocks bolted to the wheel spokes could be made to operate it.

The results of the test are given in Table II, and indicate that the internal double-run type of force feed will drill fine limestone when a suitable agitator is used in the drill hopper.

With coarse limestone for our past experience, the opinion naturally arises that the drilling of limestone through the regular seed runs of grain drills will cause excessive wear and consequent inaccuracies in subsequent drilling of grain and seed. The trials reported here did not include tests on this point, though such are contemplated. The finely ground limestone, however, is widely different from the commonly used, coarsely ground agricultural limestone. This finer material is impalpably fine, and resembles flour more than it does the common agricultural limestone. Its fluffy nature and ease of agitation through failure to pack as does the coarser material suggests that any wear on the drill by such material would be relatively small. Further, it is of neutral reaction—neither acid nor alkaline—with no corroding effect on metal. While there may be some wear, the seriousness of this remains to be established by experiment or experience.

In all of the trials there was a surprising uniformity in the rate of delivery per spout, and calculations based on the lowest spout rate and the highest spout rate were never widely different. Th variations were certainly within the limits of accuracy commonly demanded in such farm operations.

The results of these trials as given in Table II indicate that present drilling machinery will distribute the finely powdered limestone effectively and in rates that easily accommodate the amounts suggested by soil experiments with this fine limestone.

(AUTHOR'S NOTE: The authors are indebted to Wayne H. Lowry, student in agricultural engineering, for assistance in making the tests reported in this paper.)

Photoelectric Method of Determining Chalkiness of Rice

(Continued from page 105)

From the standpoint of operating a photoelectric relay to give a visual signal, as with a lamp, to indicate whether a kernel is chalk or not chalky, it appears desirable to operate a given lamp at a voltage high enough to produce a current which will operate the relay satisfactorily. A device operated by such a relay is being designed to sort out automatically the chalky kernels from analytical portions of samples.

The preceding discussion has referred practically entirely to brown rice. Milled rice is brown rice from which practically all of the bran coat has been removed by the milling process. Preliminary tests with milled rice show that such rice can also be analyzed for chalkiness by the same method, and in addition by means of reflected light. Chalky kernels of milled rice, when subjected to the highly concentrated beam of light, emit a dazzling white light that affects the photoelectric cell readily, while the non-chalky kernels give a very much modified reflection with a corresponding lower cell response. This property permits handling the rice without the aperture mentioned in connection with brown rice.

Correspondence

Letters discussing subjects of particular interest to agricultural engineers or the contents of this journal, and comments from members of the American Society of Agricultural Engineers on activities and policies of the Society, are welcome. Readers are invited to make the fullest use of this department of AGRICULTURAL ENGINEERING.

Pneumatic Tires for Tractors

To the Editor:

The February issue of AGRICULTURAL ENGINEERING bubbled over with enthusiasm on this subject. To those who read this issue, it would lead to the conclusion that all this material was based on facts and that we had definitely reached a point where anything but a low-pressure air tire on a tractor was out of date and doomed to failure, so far as economic performance was concerned. This issue, therefore, prompts the writer to bring out some points that may throw a little light on this subject, from the other side. It will be my purpose to mention some of the things that I said on the floor of the meeting of the A. S.A.E. Power and Machinery Division (November 29, 1932), in Chicago when this subject was discussed, and where papers that appeared in the February Journal were read. I cannot expect to repeat exactly what I said there and will add considerably more which, for the sake of time, was not mentioned by me at that time.

Tradition is a handicap. We are prone to tie our faith to what always has been customary. It is difficult for us human beings to change out attitude. This refers not alone to mechanical change but to mode of life, to economic values—in fact, almost everything. We are victims of habit.

I have always prided myself on having an open mind and not being susceptible to this handicap of tradition with reference to agricultural-engineering subjects. I find myself, however, somewhat hindered and handicapped from what has been said and from what has appeared in print as representing good engineering judgment and in advertisements of people who manufacture pneumatic tires.

Let it be understood right now that I still am open minded and willing to be convinced that farm tractors will eventually operate on rubber, that is, whether they are crawlers or wheel tractors. This may be remote, but I would be the last one to say it is impossible. That this is accepted as a fact today is in accord with what I believe is true.

In times like these, we are very apt, as manufacturers, to grasp at a straw as a means to induce sales. Probably some have been overenthusiastic in this matter of pneumatic tires and let their better judgment become overbalanced by their enthusiasm. This enthusiasm is a product of a balance sheet to which the manufacturer may be looking as a means of perpetuating himself.

The enthusiasm of the manufacturer of the product in preparing material that may be a fact relating to a particular and specific case is also apparent. Here too an eagerness to anticipate a volume as a means to profit is in the foreground that may and is quite apt to warp good judgment with reference to the future. It is for the long pull that we must really consider these things.

Danger to the industry is a serious matter. Those of us who have been associated with this industry all our lives, are concerned in this matter. We have seen things done, even a considerable amount of material sold, that has reacted negatively on all of us—in fact, on many who were not even a party to doing these things that brought about the reaction. It always strikes home and reflects on the industry.

If pneumatic tires on tractors should turn out to be like many other propositions which have been advanced and fail in general, the industry would become the victim and be called unstable. It never reflects on the manufacturer of a particular accessory, such as a tire, which is a very small part of a tractor. No blame will be attached to him, because his contribution to other industry has been so profound and of so much value that he has established himself firmly in the minds of the public at large. Farmers, however, to whom we must cater and serve are the ones with whom we are concerned. It is the ultimate consumer who buys commodities from us that we have in mind and that I am thinking of particularly.

This industry has served him well—in fact, the history of agriculture is the history of the development of farm equipment. To fail now would be folly, and it is far from the purpose of anyone in this industry to do anything that would injure the farmer and do it willfully. Of this I am sure.

The college men have accepted this material on low-pressure tires in its entirety—apparently swallowed it hook, line, and sinker—when, above all others, they should accept it with a grain of salt, knowing the variables that are encountered in the performance of tractors (and wheels particularly). They are the ones, rather than the manufacturer, who should raise the question and get some facts in the case and present them. It is these very facts covering the variables found in agriculture that are lacking. One swallow doesn't make a summer; neither does the good performance of a single pneumatic tire on a particular farm establish facts that will make their acceptance general as a farmer's commodity from which he expects to make a profit. This is the thing that disturbs me personally.

The national corn picking contest at Galva, Illinois, last fall was attended by, we are told, from fifty to sixty thousand farmers. Other than the crawlers and one wheel tractor with lugs, all tractors there were equipped with low-pressure pneumatic tires. The rain of the night before coupled with that of the preceding day made the ground rather "slick" on top. If it hadn't been for the few crawlers and the one wheel tractor with lugs, they would probably be there yet. Here was a demonstration before a tremendous group of farmers and representative men where, in some instances in the wet spots, these low-pressure, pneumatic-tired tractors were unable to even propel themselves, much less carry a load. It demonstrated to these fifty or sixty thousand farmers that we haven't "arrived" as yet. From the farmer's standpoint, it was a "flop," and it has built up a resistance to an acceptance of this thing by just that many men, and is multiplied by the number to whom this story has been repeated.

The traction of these rubber-tired tractors bears some relation to the type of soil upon which they are working and whether it is wet or dry. This also bears some relation to the weight of the unit.

In general, it is not far from the fact in stating that these rubber-tired tractors are efficient only in high gear and at relatively high speeds. In intermediate or in low, nine times out of ten they would be unable to pull any more than 25 per cent of their weight and never equal the performance of a tractor with lugs on wheels. A farmer buys a tractor as a means to profit. He must use it in the dry days of summer on hard clay ground, and he must use it for plowing his corn with a rotary hoe, if he chooses, on a relatively soft field. He must also use it in the spring and in the fall. He must pull his corn picker when there is snow on the ground and often ice and sleet and dampness. He is unable to choose the days that would be favorable to the pneumatic-tired tractor. He demands drawbar pull. The rubber tire people are advertising that "there is an increase in power." In general, isn't it quite likely that the farmer may be thinking of "drawbar pull" as the same thing, and this is misleading

Pneumatic-tired tractors we are told do not pack the ground. It might be well for those who make this statement to observe their performance where they work well, and that is in pulling a rotary hoe at high speed for some of the early cultivation of corn, and to notice that even here under some soil conditions the rotary hoe will not even disturb or entirely remove the tracks of the rubber-tired wheels in the field. Does this look like packing?

Photographs will reveal this clearly. Can it be that this has been overlooked?

A wheel tractor with lugs and a narrow rim tire will actually aid in cultivating. It may seem like an expense to put these lugs into the ground, causing them to penetrate, and again to take them out, but if they aid in the work that some of the tools operated with the tractor are performing, isn't it money well expended in the direction in which the farmer is interested?

Considerable talk has been presented to indicate that some of the handicaps may be overcome by the use of chains or lug arrangements of some kind. That may be possible. Wouldn't it, however, defeat just exactly those things which they are supposed to overcome? If lug equipment of some sort or other is to be used on a pneumatic tire, or even chains, wouldn't it be an admission that they have their limitations?

Is it possible that we are to presume that a farmer should have two sets of wheels—one pneumatic tire and the other the conventional type steel wheels and lugs?

On the highways we are told considerable advantage may be had by moving from farm to farm. This is quite likely and sounds very reasonable, but I am wondering whether the farmer buys his tractor primarily to move from farm to farm or to work on the farm. Isn't it really incidental to his general problem?

For hauling on the highways there is some advantage, of course, in that speed may be maintained that would enable a farmer to get somewhere in a comparatively short period of time. May I ask what is to become of the truck if the tractor is to do this highway hauling? I am also interested in what equipment the farmer at present has that he can haul on the highways, at relatively high speeds, such as might be anticipated with the tractor. Is it our purpose to have this tractor displace or replace the trucks as a part of the farmer's equipment?

These are thoughts that come to mind and with which I am concerned. Perhaps I am crossing the bridge before I get there, but just the same I am thinking in terms of what may be conscientiously sold to a farmer as a means of reducing his cost of production.

These few thoughts presented in this letter offer a means for the writer to get this "off his chest." It doesn't seem fair to have everything presented on one side without giving thought to some of the problems on the other side, because there are nearly always two sides to every question.

I don't want to be accused of predicting what the future holds for us with reference to pneumatics on tractors. That this is possible, I am not willing to deny. That it is here today is not a fact. We must consider this matter in the light of the man who uses these things.

It is not our purpose to unload something on the farmer as a means to increase our sales, and I would personally resent it. If it is overenthusiasm, without good judgment, then let us get our feet on the ground and stand pat, so that we know that every statement we make can be backed up by facts. We should aim to give the farmer that which serves him best with the least expense as a means to a solution of a problem and that is one of supplying mechanical power with which to reduce his cost of production whether it be livestock or crops.

This letter is being written with these things in mind. I resent being stampeded into the acceptance of anything unless it has been proved sound—things on which the industry can build and that the farmer can use with success. This letter represents one person's viewpoint. I am concerned with the industry of which I have been a part for so many years, and I am presenting my views in this manner so that all of us may give it further thought.

Yours truly,

Frank N. G. Kranick.

Racine, Wisconsin.
April 3, 1933.

Book Review

"Modern Connectors for Timber Construction," is the title of a handbook just issued by the National Committee on Wood Utilization of the U. S. Department of Commerce. This handbook was prepared jointly by engineers of the Committee and the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, and introduces into this country a revolutionary method of making wood joints through the use of metal connectors, strengthening timber at its critical point and thereby making it available for wider consideration in the construction of major structures. The handbook constitutes a reintroduction to this country, in modern usable form and under economically favorable circumstances, of construction principles which were abandoned in embryonic and vaguely developed stages nearly half a century ago. These modern connectors consist principally of metal rings, plates, and disks of a dowel or semi-dowel type with teeth on one or both faces. In general and in non-technical language the connectors are placed or forced into the bases of wooden members to be joined. The members are then brought together and held by the accustomed bolt, but the bolt becomes primarily a binder and only secondarily a load-bearing unit. With their larger circumferences, these connectors make an increased load and distribute it over a larger area of the timbers, thus avoiding the undistributed unit "edge stresses" frequently experienced under bolted connections where the small diameter bolt played against the localized area of the timber face, crushing the timber at this point, and, together with bent bolts, accounting for slip with consequent sag in structures. Thus, on most conservative laboratory data, the load-bearing capacity of the joint is increased from four to six times, and in certain cases as high as twelve times that of the ordinary bolted joint. By one economist of the lumber industry this new method is described as the most important event in wood technique in more than a hundred years. The handbook contains 147 pages, amply illustrated, and may be obtained at 15 cents per copy from the Superintendent of Documents, Government Printing Office, or from the National Committee on Wood Utilization, U. S. Department of Agriculture, Washington, D. C.

"Abbreviations for Scientific and Engineering Terms" is the title of American Tentative Standards (as Z10i-1932) approved by the American Standards Association in November 1932. The abbreviations are those preferred for use in typewritten or printed text. One of the features of these standard abbreviations is the general omission of periods after abbreviations which has been recommended not only as a measure of economy but also to avoid the confusion which has been found to result from attempts to employ abbreviations for the names of metric units without periods and abbreviations for the names of English units with periods in the same publication. Copies of this standard may be secured from the American Standards Association or the American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y., at 40 cents per copy.

"Farm Structures," by Edward Richard Jones, head, department of agricultural engineering, University of Wisconsin, and state drainage engineer of Wisconsin, is the title of a treatise on surveys for and designs of systems of land drainage, irrigation, and erosion control; subdivision of fields, planning the farmstead, water systems, heating and ventilation, buildings and other structures on the farm, including sewage disposal systems. As stated by the author, the book is dedicated to the Smith-Hughes teachers of vocational agriculture in the high schools of America. It is intended to serve as a guide for elementary courses in farm structures, whether they be tile drains, terraces, dams, fences, buildings, or the equipment for buildings. The book consists of 200 pages profusely illustrated, and includes such chapter headings as Differential Levelling; Measuring Distances; Areas, Angles and Topographic Maps; Tile Drainage Systems; Control of Surface Water; Farmstead Fields and Fences; Capacity and Requirements of Buildings; Concrete Foundations and Pavements; Strength of Frame Structures; Heating and Ventilating; Water Supply and Sewage Disposal, and Cost Estimates. The price of the book is $1.25, with a discount in quantity lots, and is published by the author, College of Agriculture, University of Wisconsin, Madison.

The A.S.H.V.E. Guide for 1933 has just been published by the American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York, N. Y. This is the 11th edition of this standard reference volume on heating, ventilating, and air conditioning. It appears in an entirely new dress, and the contents have been extensively enlarged and revised to include the latest results of research in modern engineering practice. It is compiled by the foremost engineers in the profession and embodies in its 45 chapters, not only data developed at the A.S.H.V.E. Research Laboratory and cooperating institutions, but also the most practical and useful ideas of outstanding engineers in the profession. The text section of this book contains 608 pages, supplemented by 180 pages of manufacturers' catalog data, with an index to modern equipment. It contains eleven new chapters, and extensive changes have been made in the other sections which have been retained. The book is 6x9 inches in size, bound in a red leather-like cover, stamped in gold. The single copy price is $5.00.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

How to Avoid Faulty Concrete in Small Structures (Purdue University (Lafayette) Engin. Ext. Ser. No 27 (1932), pp 154, figs 95).—This bulletin presents technical information of practical use to designing and construction engineers on the proper preparation and use of concrete in small structures, with special reference to the avoidance of faulty material. Among others it contains chapters on buying and handling cement; sand, gravel, and stone; harmful substances in Indiana aggregates; aggregate sizes and gradings; water and consistency; the mix; batching; estimating quantities of materials; mixing; plant and equipment; forms; reinforcement; from mixer to forms, placing; joints, cracks in concrete; finishing concrete surfaces; keep new concrete damp; cold weather methods; water-tight concrete; special concretes; faulty concrete construction; specifications; inspecting and testing concrete; masonry and mortar; stucco; floors, walks, and driveways; walls and tanks; posts and precast work; and references and texts.

An appendix contains specifications for concrete.

Methods of Artificially Lighting Winter Layers, I. W. Rhys and R. T. Parkhurst (Rural Electrification and Electro-Farming (London) 7 (1932), No 84, pp 367-369, fig 1).—The results of experiments conducted at the Harper Adams Agricultural College are reported in which two lots of early and late hatched White Leghorn pullets were tested under lights.

The experiment showed that late hatching pullets when electrically lighted during the winter months responded to the treatment and gave better production and profit over food and lighting than unlighted pullets. The experiment also showed that satisfactory inexpensive devices could be arranged for automatically regulating the lights, that a reasonable allowance of artificial lighting had not injured the health of the birds, and that food consumption and body weight were materially increased by the use of electric light.

It was found that morning and evening lighting not only increased production but has an advantage in its convenience.

[Agricultural Engineering Investigations at the Nebraska Station] (Nebraska Agricultural Experiment Station [Lincoln] Report [1931], pp. 7-9, 22, 23).—The progress results are presented of the Nebraska tractor tests and of studies of the draft of combines, wind-driven farm electric plants, pump irrigation, the use of electric power on Nebraska farms, methods of cooling milk on the farm, washing machines, electric cooking stoves, and the relation of draft to performance of kerosene burners on kerosene cook stoves.

[Agricultural Engineering Investigations at the New Jersey Stations] (New Jersey Agricultural Experiment Station [New Brunswick] Report 1931, pp. 13-15, 61-63, 377-384, figs. 9).—The progress results are presented of studies on fertilizer distributors, ventilation requirement for poultry laying houses, mechanical means of projecting air for dusting, effects of automatic turning and positioning of eggs during incubation, tillage machinery, water supplies and sewage disposal, and sewage irrigation.

Building Framework and Foundations of Different Materials and Corresponding Space Inclosures, R. Rohn (Tragwerk und Raumabschluss eine Zusammenfassung Heutiger Konstruktionsmoglichkeiten des Hochbaues in Holz, Stein, Eisenbeton und Eisen. Thesis, Eidg. Tech. Hochsch. (Zurich), 1931, pp [4]+145, pls 22).—This book deals with lumber, natural and artificial stone, reinforced concrete, and steel as primary building materials, with particular reference to their structural strength and relative space requirements.

The Manufacture of Anhydrous Alcohol and Its Use in Internal-Combustion Engines [trans. title], A. Wiehe (Rev. Agr. Maurice, No 63 (1932), pp 96-113, pls 2).—Data and information are presented on methods of manufacture of absolute alcohol from molasses and other materials and on its use in internal-combustion engines.

A Further Note on Soils Regarding their Suitability for Making Irrigation Works Exposed to Water, J. Charlton (Agr. and Livestock in India, 2 (1932), No 3, pp 290-296).—In a further contribution to the subject, the results of studies on the coefficient of dispersion of six kyatti soils from irrigation structures are reported.

The coefficient of dispersion is the ratio of the dispersion of clay and silt in natural soil to the dispersion of clay and silt after exhaustive treatment of the soil with dilute neutral sodium salt solutions.

It was found that from the point of view of suitability of the soil for making engineering works exposed to water, not only is the coefficient of dispersion important but the total amount of clay and silt is likewise very important. The tendency toward kyatti formation may be measured by the product of a function of the dispersion coefficient and the amount of clay and silt present.

It is considered likely that when an amount of replaceable sodium is present in a soil greater than from 4 to 5 milliequivalents per 100 g of air-dry soil, the soil is likely to give trouble when used for irrigation works exposed to water.

Drilling with the Tractor [trans. title], W. Schirmer (Technik Landw., 13 (1932), No 4, pp 71-73, figs 3).—A brief comparison of grain drilling with horse and tractor power indicates that the greatest advantage of tractor power for this purpose, under German conditions, lies not so much in the cost saving as in the volume of accomplishment per unit of time, thus taking full advantage of weather conditions favorable for seeding.

Rules for Tractor Testing [trans. title] (Technik Landw., 13 (1932), No 4, pp 82-86, figs 7).—In a brief contribution from the Agricultural Academy of Berlin, a summary is given of the main features of regulations governing tractor testing which are proposed to meet German agricultural conditions. These are compared in some respects with the tractor-testing procedure used at the Nebraska Experiment Station, and data are presented showing their use on a wheel tractor of German make.

[Agricultural Engineering Investigations at the Missouri Station], J. C. Wooley et al. (Missouri Sta. Bul. 310 (1932), pp 8-11).—The progress results are presented of studies on the design of farm buildings and equipment, terracing machinery, silo filling methods and cost, grain harvesting, grain drying, tractor costs, relation of silage density to depth, rural electrification in Missouri, electric brooding, and the durability of fence posts.

Selecting the Pump, Power, and Piping for Irrigation Purposes, O. E. Robey (Michigan Sta. Quart. Bul., 14 (1932), No 4, pp 247-253, figs 3).—Tabular and graphic data are presented indicating the pump, power, and piping required for different irrigation purposes.

Saving Surface Soil and Preventing Erosion, L. B. Taft (Michigan Sta. Quart. Bul., 14 (1932), No 4, p 237-244, figs 6).—Practical information is presented on erosion prevention in Michigan orchards, special attention being devoted to terracing methods, repairing washouts and gullies, and the use of dams.

[Irrigation Investigations at the Nevada Station], G. Hardman, R. Stewart and F. L. Bixby, (Nevada Sta. Rpt. 1931, pp 15, 16).—The progress results are presented of studies on the reclamation of certain desert soils under irrigation from artesian wells in the Las Vegas Valley of southern Nevada, which deal specifically with water supply, the relation between precipitation on adjacent watersheds and the underground water supply, and the reclamation and improvement of different soils.

[Agricultural Engineering Investigations at the Iowa Station], J. B. Davidson, E. V. Collins, W. G. Murray, H. Giese, and L. W. Forman (Iowa Sta. Rept. 1931, pp 17-22, fig 2).—The progress results are presented of studies on corn production methods, farm building losses due to wind and fire, the all-masonry barn, farm refrigeration, the use of tractors, tractor track efficiency, draft of farm implements, silo wall treatments, prepared roofing, limestone and fertilizer distributors, and efficiency of a barn ventilation system.

Water Survey of Cimarron County, Oklahoma, H. W. Houghton ([Oklahoma] Panhandle Sta., Panhandle Bul. 38 (1932), pp 29, pl 1, fig 1).—The results of a survey of the water resources of Cimarron County, Okla., are presented and discussed. The data indicate that a majority of the wells of the county yield water which is suitable for irrigation purposes.

Improved Placement of Fertilizers in the Hill for Corn, R. M. Salter, C. O. Reed, E. E. Barnes, and C. L. Thrash (Ohio Sta. Bimo. Bul. 156 (1932), pp 83-98, figs 6).—This is a progress report of investigations involving both controlled hand placement experiments and field performance tests of commercial corn planter fertilizer attachments.

The hand placement experiments as a whole appeared to favor the placing of the fertilizer either in a circular band, approximately 2 in wide and 3 in inside diameter, or in two parallel lateral bands, each about 2 by 8 in and separated 3 in, giving in either case a minimum horizontal distance of about 0.75 in between the seed and the fertilizer. As regards depth the fertilizer band probably should lie within a zone from 0.75 in above to 1 in below the seed, the evidence being slightly in favor of the deeper placement.

Tests also were conducted with different makes of commercial corn planters to determine how various types of fertilizer depositors place fertilizer in respect to the hill of corn and the efficiency of these types as measured by stand, height, and yield of corn. The manner of placement of the fertilizer was determined by a mutiple-plane method which was developed by the experiment station. Briefly this method consists of taking off a series of layers of soil 0.25 in thick and recording what is seen on the top plane of each successive layer. The data on each planter are briefly discussed, but no conclusions are drawn.

Housing Conditions for Chickens in Confinement, D. C. Kennard (Ohio Sta. Bimo. Bul. 156 (1932), pp 111-116, figs 2).—Practical information is given on the housing of chickens in confinement, with particular reference to the admission of natural daylight.

The Farm Home, F. A. Cuthbert (Oregon Sta. Bul. 293 (1932), pp 56, figs 36).—This bulletin contains practical information on the selection of a farm home site, choice of farm residence, and landscaping the farm home. An appendix contains house and garden plans, relating especially to the remodeling of houses and cottages, the design of a 7-room house and grounds, and certain special garden designs.

The Trench Silo, J. T. McAlister and C. W. Stroman (Clemson Agr. Col. S. C., Ext., Circ. 121 (1932), pp 16, figs 12).—Practical information on the construction of trench silos is presented, together with numerous illustrations and working drawings.

Cost of Pumping for Irrigation in Colorado, with Data, W. E. Code (Colorado Sta. Bul. 388 (1932), pp 69, figs 13).—This bulletin presents additional results of a special study of the cost of pumping for irrigation covering a period of two years and under conditions that were representative of practice in the northern and southern parts of Colorado.

Although direct comparisons could not be made fairly, in general it appears that electric pumping by means of a properly proportioned plant on the ordinary sized farm of between 80 and 160 a will prove as cheap a means as any for providing irrigation water.

The Construction and Management of Air-Cooled Storages with Special Reference to Apples, R. E. Marshall (Michigan Sta. Circ. 143 (1932), pp 43, figs 32).—This bulletin brings together considerable data and information secured in different investigations at the station relating to air-cooled storages for apples. It deals especially with mechanical refrigeration and the principles of air-cooled storage, and contains other sections dealing with the rate of ripening in air-cooled storage and cellar type above-ground storages. Practical information is also included on construction, with particular reference to ventilation and equipment.

Grain Elevating Machinery for the Palouse Country, H. L. Garver (Washington Col. Sta. Bul. 262 (1932), pp 34, figs 20).—This is one of a series of bulletins dealing with the use of electricity on the farm, which is the result of studies conducted by the experiment station in cooperation with the Washington Committee on the Relation of Electricity to Agriculture. It presents the results of experiments on grain-elevating machinery suitable for the Palouse country of Washington.

It was found that the power requirements of some types of elevators are much greater than those of others, yet the cost of energy for the operation of any of these outfits is so small compared with the cost of manual labor that it seems extravagant to do the work by hand. The cracking of the grain did not result in changing the grade. The reduction in per cent germination was not positive enough to justify discrimination against the pneumatic elevator in view of its other advantages.

Other practical information on the selection and installation of elevating equipment is presented.

Parshall Flumes of Large Size, R. L. Parshall (Colorado Sta. Bul. 386 (1932), pp 55, figs 28).—This report is based on data gathered under a cooperative agreement between the U.S.D.A. Bureau of Agricultural Engineering and the station. It brings together the information and experimental data relating to large size Parshall flumes.

The data indicate that this measuring flume has been found accurate enough to meet practical irrigation requirement under conditions where sand and silt have given trouble in the old type of rating flume. The range of capacity extends from less than 0.1 cfs for the 3-in flume to more than 2,000 cfs for the 40-ft flume. The successful operation of the flume depends largely upon the correct setting of the elevation of the crest above the grade of the channel and on precise construction to correct dimensions. It is recommended that these flumes be built in straight canal sections.

Data of a technical character are presented on the design of flumes for special conditions.

Plans and Specifications for Two Types of Trapnest, W. C. Thompson (New Jersey Stas. Hints to Poultrymen, 20 (1932), No 7, pp 4, figs 4).—The plans presented are for the so-called Eno trap nest and the Connecticut trap nest as revised for New Jersey conditions. Brief specifications for these are included.

Pinking in Internal Combustion Engines, K. Schnauffer (Fuel, 11 (1932), No 8, pp 298-302, figs 9).—In a contribution from the German Aircraft Experiment Station, the results of laboratory studies on pinking in internal-combustion engines are reported.

The results indicate that in an internal-combustion engine that is not pinking the flame propagates from the spark plug with a speed that is almost uniform. When pinking occurs the whole of the unburned portion of highly compressed gas mixture ignites spontaneously after reaching the self-ignition temperature. Due to the simultaneous inflammation of a large part of the gas mixture, large increases of temperature and pressure occur. The energy transformation is so direct, that is, it occurs so rapidly, that large local pressure differences occur which equalize with the speed of sound. In normal combustion a uniform pressure prevails owing to the low speed of propagation of about 25 m per second.

The intensity of the pinking depends on the amount of unburned gas mixture remaining when pinking is set up and on the composition (fuel-air ratio) of the mixture. As a measure of pinking, one can either take the measured direct pressure increase at the pinking center, or determine the mixture ratio that will give simultaneous inflammation. Due to the large local pressure differences during pinking, it is not immaterial at what position the recording of the pressure takes place.

In addition to the main form of pinking, there are also three other forms of pinking which may easily be differentiated from one another by means of the pressure records. The ionization current increases when pinking occurs due to the increased temperature. This increase can amount to several hundred per cent.

When pinking is absent, after-burning occurs until the exhaust valve opens (flame is projected through the open exhaust valve.) With intense pinking, the combustion is so rapid that after-burning does not occur (no flame projected). If the amount of gas inflamed simultaneously is very large then, due to the expansion of this burning gas mixture, a high negative speed of propagation occurs.

Journal-Bearing Friction in the Region of Thin-Film Lubrication, S. A. and T. R. McKee (S.A.E. [Soc. Automotive Engin.] Jour., 31 (1932), No 3, pp 371-377, fig 13).—Studies conducted at the U. S. Department of Commerce Bureau of Standards are reported.

Tests made in a four-bearing machine, using both high-tin babbitt and high-lead bronze bearings and operated on lubricants of various viscosities over a wide range of speed and load, showed conclusively that the coefficient of friction depends directly upon the viscosity even in the thin-film region. They indicated definitely that the friction coefficient is more likely a function of $ZN \div \sqrt{P}$ than of $ZN \div P$. It was found also to depend upon the metal of which the bearing is constructed, whereas, in the region of thick-film lubrication the coefficient of friction is independent of the composition of the bearing metal. **Z** is the absolute viscosity of the lubricant, **N** the speed of the journal and **P** the bearing pressure.

Soil-Loading Test Practice in Europe, K. Terzaghi (Engin. News-Rec., 109 (1932), No 6, pp 158, 159).—The author describes and appraises the apparatus and methods devised by European engineers for determining the ability of soils to carry foundation loads.

Compressibility of Clay Increased by Remolding, A. Casagrande (Engin. News-Rec., 109 (1932), No 6, pp 159-161, figs 5).—In a contribution from the U.S.D.A. Bureau of Public Roads, a description is given of tests conducted at the Massachusetts Institute of Technology which showed an increase of compressibility of remolded clay compared with the same clay in the undisturbed state.

The opinion is reached that a foundation in clay must be designed so that for any possible stress distribution no harmful differential movements can occur. This means that the foundation should be rigid enough to prevent any appreciable bending. A foundation slab alone can not accomplish this in an economical way. In order to make a raft foundation rigid enough and at the same time not excessively heavy, it must be designed as a truss, combining as its members the whole basement.

Foundation Soil Overloading Shown by Penetration Test, H. K. Stephenson and E. B. Feingold (Engin. News-Rec., 109 (1932), No 6, pp 161, 162, figs 3).—In a contribution from the University of Michigan, a practical application of the principles of soil mechanics is described.

Tests on Tin-Base and Lead-Base Bearing Metals, C. Jakeman and G. Barr (Engineering [London], 133 (1932), No 3448, pp 200-202, figs 6).—Studies are reported which indicated that an alkali metal-lead alloy will run satisfactorily at moderate loads and temperatures when lubricated with mineral oil or compounded oil, but that the alloy freely dissolves in olive or sperm oils. The general conclusions drawn from the whole investigation are that neither high-lead nor high-tin alloys are readily attacked by the lubricants in common use, such as mineral oil, compounded mineral oil and castor oil, but that generally speaking a higher friction loss will occur with a high-lead alloy than with a high-tin alloy.

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Raymond Olney, Editor

R. A. Palmer, Associate Editor

Motor Fuel from the Farm

THAT agricultural engineers are interested in alcohol as a possibly practical motor fuel is being indicated in the preparations under way for the session on agricultural engine research to be included in the program of the annual meeting of the American Society of Agricultural Engineers at Purdue University in June. Certainly no group can more devoutly wish for fuel alcohol as a market for farm crops, and none has brighter hopes or clearer vision in the whole matter of industrial uses as a market for agricultural products.

Though there is now in prospect some spirited discussion, our profession will be largely free from emotional thinking and temporary enthusiasms. We can hardly forget the promises of tax-free denatured alcohol when its manufacture was first legalized. Still we must recognize new conditions and considerations. We now face, apparently, a continuing surplus-producing capacity in agriculture. We know, of our own achievement, that production costs of our major grains can be much lower than when denatured alcohol was a mooted question.

At that time alcohol was offered as a somewhat inferior substitute for gasoline at a competitive price—a hope that never came true. Now it must be looked at as an ingredient of a superior motor fuel, subject to production economies which may make it competitive with straight petroleum derivatives, or of such products treated with anti-knock "dopes." Since such a blend may contain any desired amount of the so-called starting fractions, engineers may dismiss the "hard-starting" argument. So, too, shellac or other alcohol-soluble materials are no essential part of fuel systems.

But engineers should not dismiss unheeded the possibility of trouble in the crankcase from alcohol and its reaction products interacting with the lubricating oil and its decomposition products. Less likely, probably, but not to be overlooked by engineers, is a possibility of new kinds or amounts of organic acids which might contribute to corrosion.

In the combustion chamber and exhaust system there is promise of reduced detonation, lowered maximum temperature, and less combustion residue, all of which should be studied and evaluated. These are considerations especially important with the tractor in relation to value performance and the facilities for and costs of combustion chamber cleaning.

Indeed, there are many angles from which it seems logical that the development of alcohol-blend fuels should be keyed to the farm tractor. It would help to deflate the argument that the tractor is not a hay-burner. Being a nonhighway use, fuel for tractors might fairly be freed of the gasoline tax as a subsidy to encourage the early production and adoption of blended fuels. Some such encouragement in the early stages of manufacture has ample precedent in the "infant-industry" doctrine of the protective tariff.

While the legal and political aspects of the matter do not belong to engineers, it seems proper to remark that both the present temper of the American people and the traditions of American practice both indicate that any legislative encouragement offered to alcoholic fuels should be permissive rather than compulsive in form. And while a budding industry may be given the benefit of tax waivers and protection against unfair competition, most engineers will agree that such advantage should be temporary, and that when full-scale production is attained alcoholic fuel should hold its own by sheer economic merit.

Strictly speaking, fuel alcohol is the business of the agricultural engineer only in the production and delivery of the raw material to the factory, and in the employment of the finished product. Actual manufacture belongs to the chemical engineer, and once he is admitted the question is no longer one of ethyl alcohol, but of a whole list of organic products. There may be several of value as fuel components, and almost certainly there will be many of other technical utility and economic value. Quite likely they will have to rank as co-products rather than by-products, for alcohol as a sole or main product gives little promise of being able to compete with, or as a part of, petroleum fuel.

W. B. JONES.

Landmark in Building Plan Service

THE COOPERATIVE building plan service on which the Structures Division of the American Society of Agricultural Engineers has been at work for some years, has made such progress as to deserve comment, both as an achievement made possible by the Society organization, and as an example of the capacity of agricultural engineers to cooperate in the interest of economy and more perfect service to the farmers of America.

With thirty-eight states and the federal bureau just mentioned all offering service in building plans, it has long been felt that there was a duplication of effort and cost in the creation of plans. There were seeming clashes of recommended practice at state boundaries. Mechanical production of the plans was split up into units too small for real economy. Indeed, in the creation of the plans there was room for broader counsel and more intensive correlation of cost with utility.

On the other hand, the various states and regions presented such a diversity of climatic conditions, of crops and crop disposal, of livestock and livestock management, of sanitation needs and codes, and in availability and cost of building materials, not to mention the range in size of farms, as to make national standardization neither feasible nor desirable. To reconcile these conflicting considerations, to achieve at the same time both economy in administration and greater perfection of service to the farmer, is a problem of vast detail and its solution, even in part, a momentous accomplishment.

This project is an example of the way agricultural engineers serve American agriculture and related industries, and of the way that our Society enables them to serve better and at lower cost. The project is unusual mainly in the difficulties being overcome, and in the fact that its nature has kept it from getting the attention that its magnitude deserves.

A.S.A.E. and Related Activities

1933 A.S.A.E. Annual Meeting Program

PLANS for the program for the 27th annual meeting of the American Society of Agricultural Engineers to be held at Purdue University, West LaFayette, Indiana, June 21 to 24, are practically completed, as announced by E. R. Jones, chairman of the 1932-33 Meetings Committee of the Society. The program in full will be published in the May issue of AGRICULTURAL ENGINEERING.

Following the plan of the past few years, the College Division of the Society will present its program, devoted to various phases of resident teaching, extension, and research in agricultural engineering, on the first day of the meeting, Wednesday, June 21.

The first general session of the meeting will be held Thursday forenoon, June 22, and will be opened by the president's annual address by Charles E. Seitz, professor and head of the department of agricultural engineering, Virginia Polytechnic Institute. The subject of Mr. Seitz' address is "Agricultural Engineering and Rural Living."

The second general session will be held on the forenoon of Friday, June 23, which will feature four addresses on subjects of particular interest to agricultural engineers at this time. This includes one devoted to the subject of engineering in its relation to home economics, a summing up of progress in rural electrification, an economist-engineer's analysis of the agricultural situation, and an engineering dean's view of the present status of the engineering profession.

The annual dinner of the Society, at which time the second annual award of the McCormick medal will be made, will be held on the evening of June 23.

The third and last general session of the meeting will be held Saturday forenoon, June 24. This program will feature a paper on recent developments in heat insulation, a technical paper by the recipient of the McCormick medal, and three short papers by winners in the A.S.A.E. agricultural engineering students' competition.

The sessions of the four technical divisions of the Society will be held during the two afternoons of June 22 and June 23. On the afternoon of June 24 all four divisions will participate in an inspection trip to the Coffing Brothers Orchard near by. A feature of this trip will be a short program (at the orchard) of technical papers featuring portable and stationary spraying, refrigerating equipment for cold storage, and machinery for orchard tillage.

The program of the Rural Electric Division will feature two important symposiums, one on the uses of light in agriculture including the effect of light on plants and animals and insect control with light, and the other on electric soil heating and electric soil sterilization. In addition there will be papers and reports on the design and construction of farm refrigerators, motor control and protective devices, electric brooding, new methods of metering farm customers, and the discussion of a new type of wiring material for farm buildings.

The program of the Structures Division will include technical papers on (1) a study of 100 dairy barns in Wisconsin, (2) the disposition of drainage from milking barns in metropolitan districts, (3) dairy corral surfacings, (4) lightning protection for farm buildings, and (5) contributions of committees on farm fire prevention and protection, grain storage, farm house standards and design, and coordination of building plans.

The Power and Machinery Division will devote a considerable part of its program to the general subject of soil dynamics. A technical paper on this subject will be presented at one of the general sessions and at the division session following will be presented a paper on the measurement of seedbed tilth and a paper on the relation of soil tilth to cotton production. An interesting analysis of the improvement made in farm machinery the past twenty years will be a feature of this program. It is expected that a particularly interesting number on this program will be a contribution from the Committee on Row Crop Investigations. One of the sessions of the program of this division will be devoted exclusively to the subject of agricultural engines, a feature of which will be the general subject of motor fuels.

The subject of land reclamation occupies a prominent place in the projects of the new federal administration at Washington, and present plans provide for a program to be presented by the Land Reclamation Division which will be formulated largely on the basis of the contributions agricultural engineers are in position to make in connection with these projects.

An added incentive this year for members of the Society and others interested in agricultural engineering to attend the A.S.A.E. annual meeting is the opportunity offered to visit the Century of Progress exposition at Chicago. The week following the A.S.A.E. meeting will be "Engineering Week" at the exposition and will provide many attractions for engineers in all branches of the profession.

Necrology

WILLIAM DRAPER BRINCKLOE, architect and author, and a prominent figure in the activities of the Structures Division of the American Society of Agricultural Engineers, passed away at his home in Easton, Maryland, on March 6. Mr. Brinckloe was born at Wilmington, Delaware, and was graduated from the University of Pennsylvania in the class of 1893, after which he followed the profession of architect throughout his lifetime. In addition to being a member of the A.S.A.E., he was a member of the Baltimore Chapter of the American Institute of Architects, of the Committee on Farm Fire Protection of the U. S. Chamber of Commerce, and of the National Fire Protective Association. He was a retired major in the Quartermasters Corps, U. S. A. He was a past-president and one of the organizers of the DelMarVa Volunteer Firemen's Association, and a past-president of the Easton Fire Department and member of the board of trustees. He was the author of a book, entitled "The Small Home," on the shelves of the principal libraries throughout the country; "The Volunteer Fireman," at present on the press of a Boston publisher; and of many pamphlets and papers on rural fire protection, on which subject he was nationally known as an authority. For twelve years he did important work in connection with fire fighting and fire protection.

New ASAE Members

Frank C. Hughes, experimental engineer, Minneapolis-Moline Power Implement Co., Minneapolis, Minn.

Carl R. Rolen, manager, Waukesha branch, Oliver Farm Equipment Sales Co., Waukesha, Wis.

Transfer of Grade

Norman W. Wilson, assistant professor of agricultural engineering, Alabama Polytechnic Institute, Auburn, Ala.

Applicants for Membership

C. L. Burlingham, manager, dairy division, James Manufacturing Company, Fort Atkinson, Wis.

John Felder Charlton, appraisor, civil engineer, surveyor, and farmer, Box 2087, Fort Lauderdale, Fla.

Jerald E. Christiansen, junior irrigation engineer, agricultural experiment station, University of California. (Mail) P. O. Box 393, Davis, Calif.

Agricultural Engineering Digest

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The Rothamsted Pachimeter, R. K. Schofield and G. W. S. Blair (Jour. Soc. Chem. Indus., Chem. and Indus., 51 (1932), No 10, pp 205, 206, fig 1).—In a contribution from the Rothamsted Experimental Station, a laboratory machine is described and illustrated which is designed to measure the physical and dynamic properties of plastic materials such as soils, wheat flour doughs, and the like. Its primary function is the measurement of shearing strength, although apparently it may be modified to measure other properties such as plasticity, viscosity, elasticity, and the like.

A piece of plastic material is made into a cylinder of known radius and length. This is placed between two plates, the upper of which is fixed to one end of a long horizontal beam. The beam is pivoted at the other end and thus allows the plate free vertical movement. The lower plate is moved to and fro with sufficient amplitude to cause the test cylinder to turn at least one complete revolution. It is found that no permanent lengthening (and simultaneous thinning) occurs unless the upper plate is exerting more than a certain critical stress on the test cylinder. The machine is designed to measure this stress.

The Corrosion of Steel by Breeze and Clinker Concretes, F. L. Brady ([Gt. Brit.] Dept. Sci. and Indus. Research, Bldg. Research, Spec Rpt. 15 (1930, pp IV+15, figs 4).—The results of studies are reported which show that concretes in which breeze and furnace clinker aggregates are used cause the rusting of steel reinforcement. The degree of corrosive power of a variety of aggregates tested increased with increasing sulfur content. Probably as a result of their absorptive powers, breeze and clinker aggregates promote rusting of steel, even under dry indoor conditions.

Owing to the physical structure of breeze and clinker aggregates, concrete containing them is usually rather porous. This allows ready access of moisture and oxygen and so permits rapid rusting. The permeability is not, however, the prime cause of the corrosion. A degree of permeability of ordinary concrete which would not allow early rusting of steel will, if resulting from the use of breeze or clinker containing sulfur, cause rapid corrosion. The substitution of sand for the finer part of coal residue aggregates reduces rusting.

The only clinker which when used in 1 : 6 concrete did not cause the rusting of steel in six weeks under moist conditions was a well-fused clinker, low in sulfur, of unusually high quality, from which all the fines were removed and replaced by sand. When the fine aggregate was not removed corrosion occurred.

The investigation is considered to prove the undesirability of using coal residues as aggregates in concrete reinforced by or in contact with steel. Though the tests do not quite exclude the possibility that the very best qualities of clinker, used only as coarse aggregate, might be harmless, the suitable clinkers are so rare and the conditions under which they have been shown not to cause rusting in a limited period are so restricted as to justify a general prohibition.

The Flow of Water Through Groups of Sluices: Experiments on Scale Models, with Particular Reference to the Effects of Mutual Interference, H. Addison (Inst. Civ. Engin. [London], Select. Engin. Papers, No 105 (1931), pp 48, figs 15).—Laboratory experiments on scale models to investigate the effect of mutual interference between adjacent sluices of a group are reported, which were conducted at the Royal Egyptian School of Engineering at Giza.

Three models in all were tested, the first having four vents 20 cm wide, the second four vents 10 cm wide, and the third three vents 10 cm wide. The first two were geometrically similar in all respects. In all the models the general proportions of the vents, piers, and gates were reproduced from drawings of the Assiut Barrage and Ibrahimia Canal Head Regulator. Each series of experiments consisted of an average of six or eight sets of observations, under conditions of uniform discharge as nearly as could be managed, alterations being made only in the downstream water level, which was adjusted by the outlet door at the tail of the escape channel.

The arrangements of the models included (1) gates lifted clear of water, (2) water flowing over top of gates, (3) water flowing between lower gates and floor, and (4) water flowing between upper and lower gates.

All the formulas suggested for calculating values of the coefficient of discharge under various conditions have been put in a form yielding pure numbers, and they are thus independent of the scale of the apparatus and of the units involved. It is therefore simple to apply them directly to the results of full-scale observations.

The results in general show that in the particular kind of submerged orifice experimented on, the overall loss of head, under given conditions, consists of a fixed quantity diminished by an amount representing recovery of head, which is itself a function of the ratio: area of gate-opening ÷ area of channel. They also show that the most convenient arrangement of the gates is either (3) or (4) above, in which the height of the lower gates is small compared with their width.

It was found that, in general, as the downstream level rose, the surface flow progressively altered from a rapid flow in a downstream direction to a state of complete quiescence and, finally, in many cases to a brisk upstream movement into the vents, proceeding from eddies which rose to the surface about half way between the regulator and the downstream gauge point. With water flowing between the gates, a very pronounced stationary wave, having a height of perhaps a quarter of its length, completely filled each vent at low downstream levels and high rates of flow, and only subsided when the upstream water level had reached nearly to the top of the piers.

Closing any of the vents either reduced the discharge through each of the remaining vents for a given difference of level upstream and downstream or increased the drop in head through the regulator for a given discharge per vent. The larger the number of vents closed the more pronounced was the effect on the discharge or levels. The effects did not depend materially on the relative position of the open and closed vents, i.e., closing the two outer vents of a group of four had sensibly the same effect as closing the two inner ones, but closing the end one alone of four did have less effect than closing an intermediate vent.

If the downstream water level was high enough to influence the flow at all, interference operated downstream of the gates as well as upstream, and the greater the recovery of head downstream with all vents open the greater was the extent of downstream interference. Upstream interference depended in amount upon the ratio of height of gate opening, or head over gates, to a depth of water around upstream pierheads, and can therefore be attributed to cross currents set up in the attempt of water from the whole width of the approach channel to enter the remaining open vents.

In those circumstances where upstream interference normally occurs it seems probable that both the shape of the upstream noses of the piers and the distance of the plane of the gates downstream from the pierheads will have some influence. If for instance the noses are of cutwater form instead of being semicircular, as in these experiments, more contraction and thus more interference would be expected, while bringing the gates further upstream should lessen interference.

On the Formation and Dispersion of Oil Sprays, K. J. DeJuhasz, O. F. Zahn, Jr., and P. R. Schweitzer (Penn. State Col., Engin. Expt. Sta. Bul. 40 (1932), pp 94, figs 55).—Studies are reported the main object of which was to establish the dispersion characteristics of fuel oil sprays employed in fuel-injection engines.

A number of experiments with various liquids were made, injecting them into atmospheric air. By observing the break-up distance the effect of several factors on spray formation was determined. For the experimental determination of the droplet sizes the spray was caught in a nonmiscible liquid medium. Microphotographs of specimens with 200 manification permitted measuring the globule diameters, and from a count of the number of various size droplets their relative frequency was determined.

The volumetric distribution of oil sprays under predetermined operating conditions was determined by the dispersion rack, which is a skeleton placed into a pressure chamber holding a number of blotting paper pads for the interception of parts of the oil spray. The spray patterns so obtained with varying oils, injection pressures, air pressures, and orifice dimensions are presented by the use of the flux lines, which offer a graphic and convenient means to compare spray patterns and judge their dispersion.

It was found that in general the dispersion of a spray issuing from a circular orifice can be represented by a bell-shaped flux curve, resembling a curve of probability, having the densest portion in the axis of the spray, which is enshroulded in coaxial cones of diminishing flux values. Under certain circumstances, the flux curve shows a rather flat top or even a crater-like depression in its central portion.

The dispersion in a given cross section becomes more even (1) as the distance from the orifice is increased, (2) as the air density is increased, (3) as the oil viscosity is decreased, and (4) as the oil pressure is increased. On the evenness of the distribution the factors enumerated have an influence approximately in the order given, i.e., factor 1 has the greatest and factor 4 the least influence.

A larger percentage of the total spray reaches a given cross section (1) as the distance is decreased, (2) as the air density is decreased, (3) as the oil viscosity is increased, and (4) as the oil pressure is decreased (within the limits of investigation). No definite influence of orifice dimensions was noticeable in using cylindrical orifices of the dimensions employed in this investigation.

Four appendixes are included dealing with mechanism of disintegration, the spray dispersion as a phenomenon of probability, practical suggestions with regard to spray disperson in fuel-injection engines, and literature on liquid jets, sprays, and nozzles, especially for oil engines.

Poultry Housing, T. B. Charles and A. E. Tepper (N. H. Univ. [Agr.] Ext. Circ. 138 (1932), pp 19, figs 13).—Practical information is given on the planning and construction of poultry houses to meet the conditions and requirements of New Hampshire. Working drawings of suggested structures are given, together with bills of materials.